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Kim

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(54) SYSTEM AND METHOD FOR A SPEAKING CHAMBER WITH VOICE CANCELLATION

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H04R 3/02 (2006.01)
G10K 11/175 (2006.01)
G10K 11/162 (2006.01)
H04R 1/02 (2006.01)

(52) **U.S. Cl.**
CPC ***G10K 11/1754*** (2020.05); ***G10K 11/162*** (2013.01); *G10K 2210/1081* (2013.01); *G10K 2210/1082* (2013.01); *G10K 2210/3224* (2013.01); *G10K 2210/32121* (2013.01)

(58) **Field of Classification Search**
CPC G10K 11/1754; G10K 2210/1081; G10K 2210/1082; G10K 2210/32121; G10K 2210/3224
USPC 381/73.1, 333
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

9,386,135 B2 7/2016 Moser
9,525,765 B2 12/2016 Moser
9,741,359 B2 8/2017 Cheung et al.
11,539,823 B2 12/2022 Yu et al.
2002/0077838 A1 6/2002 Dutta
2011/0093262 A1* 4/2011 Wittke G10K 11/17857 704/226
2022/0247852 A1 8/2022 Anvari et al.

OTHER PUBLICATIONS

Anonymous: "AIRXOM MG1 Mask", Retrieved from the Internet <URL:https://airxom-mask.com/en/shop-2/> [retrieved on Dec. 12, 2022].
Mike: "Bane-like Mask Turns Your Earpiece Into a Hush Hush Audio Mask", Retrieved from the Internet <URL:https://mikeshouts.com/bloxvox-voice-privacy-mouthpiece-mask/> [retrieved on Dec. 12, 2022].

(Continued)

Primary Examiner — Ammar T Hamid
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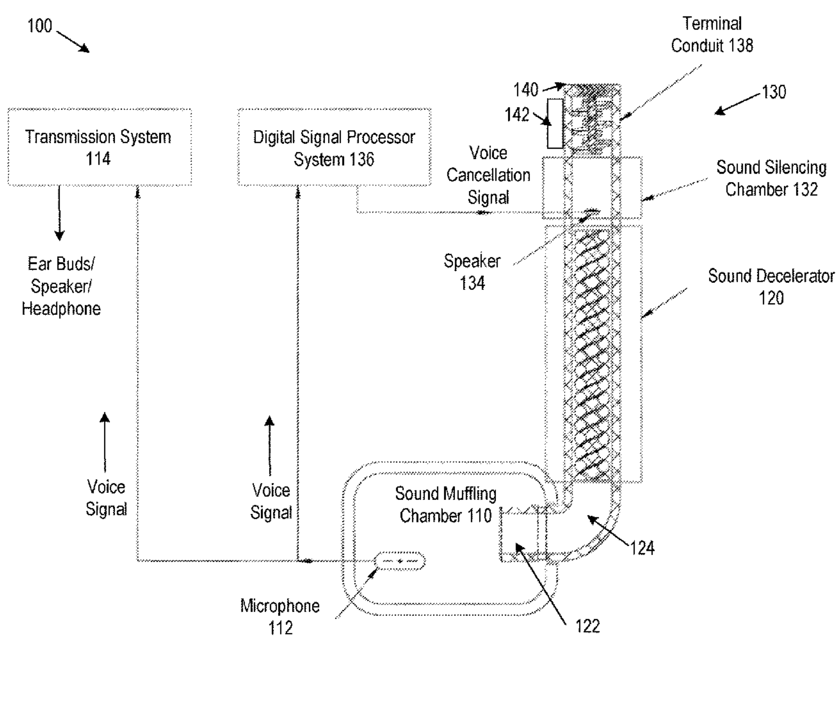
(57) ABSTRACT

A sound muffling chamber covers a nose and mouth in an airtight manner. The sound muffling chamber includes a microphone that detects vocal sound waves in the sound muffling chamber and generates a voice signal. A digital signal processing system analyzes the voice signal and generates a voice cancellation signal. A sound silencing chamber includes a speaker that generates out of phase sound waves in response to the voice cancellation signal that superimposes on and cancels the vocal sound waves. A sound decelerator is positioned between the sound muffling chamber and the sound silencing chamber and configured to increase a traveling time of the vocal sound waves such that the vocal sound waves' arrival at the sound silencing chamber may be synchronized with the arrival of a voice cancellation signal. The sound muffling chamber may include inflatable cells separated by slats such that the sound muffling chamber is foldable.

19 Claims, 15 Drawing Sheets



(56) **References Cited**

OTHER PUBLICATIONS

Anonymous: "Hushme Acoustic Device for Speech Privacy—Classic Frost White", Retrieved from the Internet <URL:https://ozrobotics.com/shop/hushme-acoustic-device-for-speech-privacy-classic-frost-white/> [retrieved on Dec. 12, 2022].

Irving: "Bizarre Bluetooth mouthpiece mutes speech in public places", Sep. 11, 2022, Retrieved from the Internet <URL:https://newatlas.com/wearables/mutalk-bluetooth-mouthpiece-mute-speech-public/> [retrieved on Nov. 17, 2022].

Anonymous: "Stenomask/Privacy Microphones", Retrieved from the Internet <URL:https://talktech.com/stenomask-steno-sr/#:~:text=STENOMASK %2F PRIVACY MICROPHONES, noise away from the microphone> [retrieved on Nov. 17, 2022].

* cited by examiner

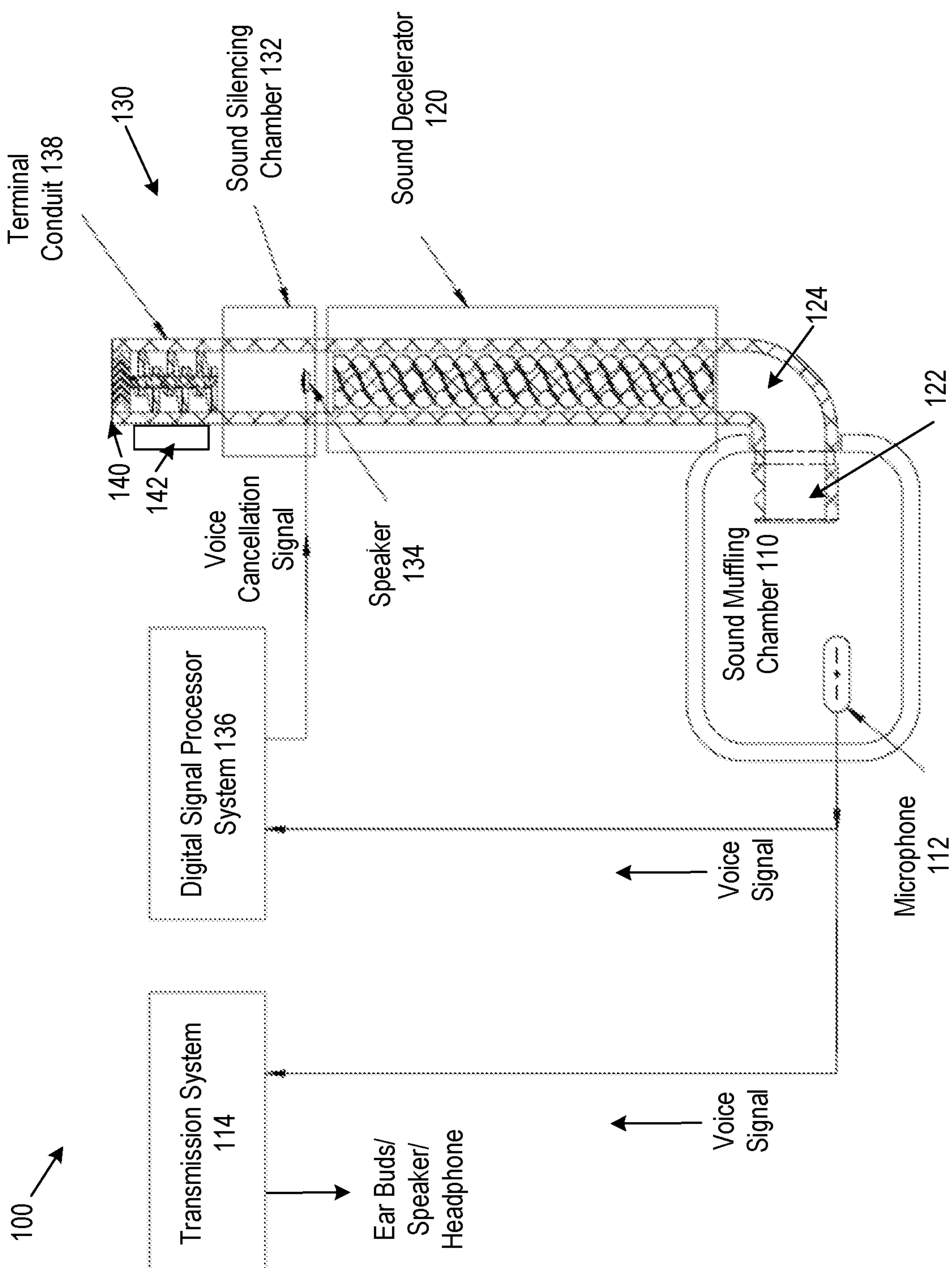

Terminal Conduit 138
130
Sound Silencing Chamber 132
Sound Decelerator 120
124
122
140
142
Voice Cancellation Signal
Speaker 134
Sound Muffling Chamber 110
Digital Signal Processor System 136
Voice Signal
Microphone 112
Transmission System 114
Voice Signal
100
Ear Buds/ Speaker/ Headphone

FIG. 1

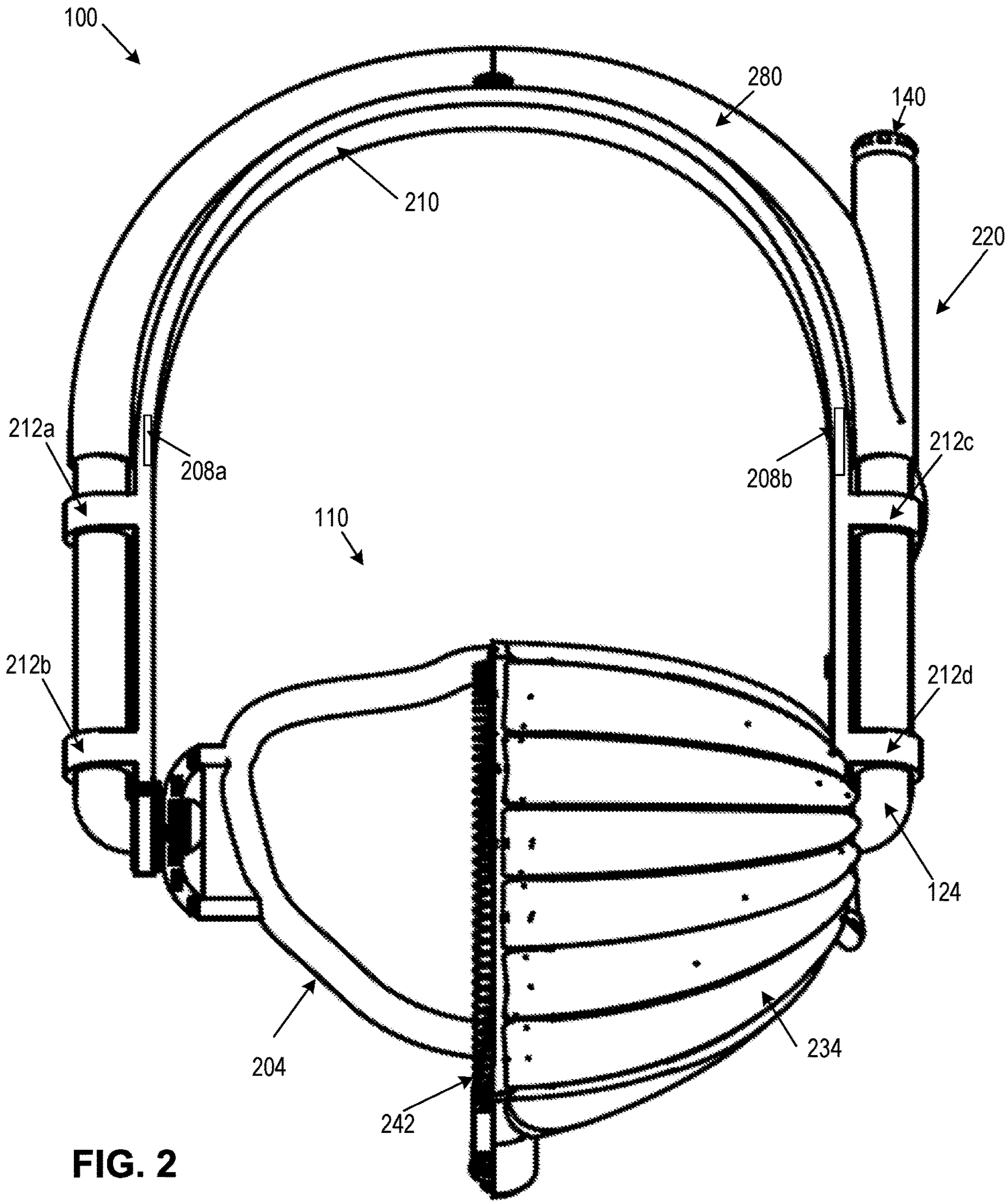

100
280
140
210
220
212a
208a
208b
212c
110
212b
212d
124
204
234
242

FIG. 2

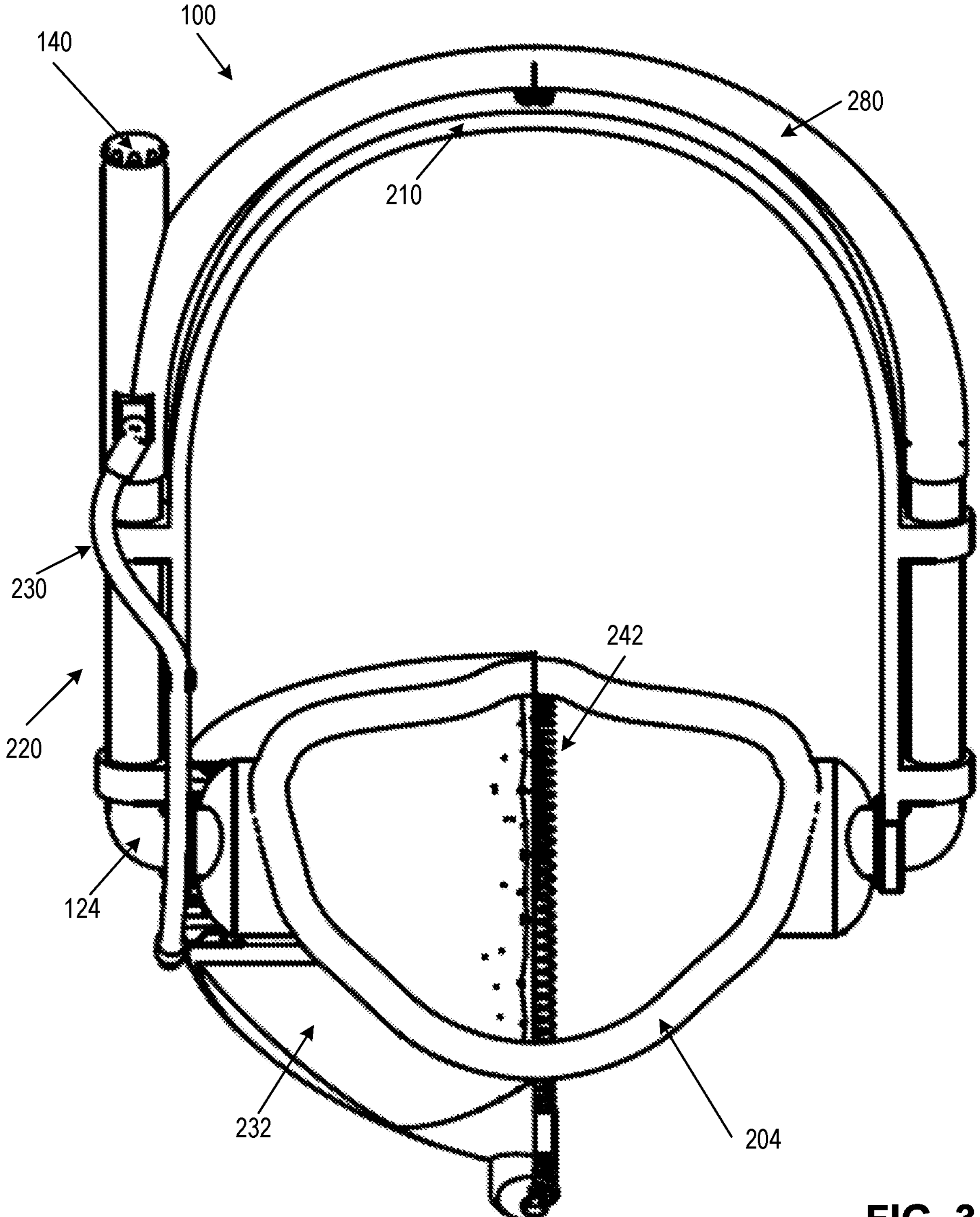


FIG. 3

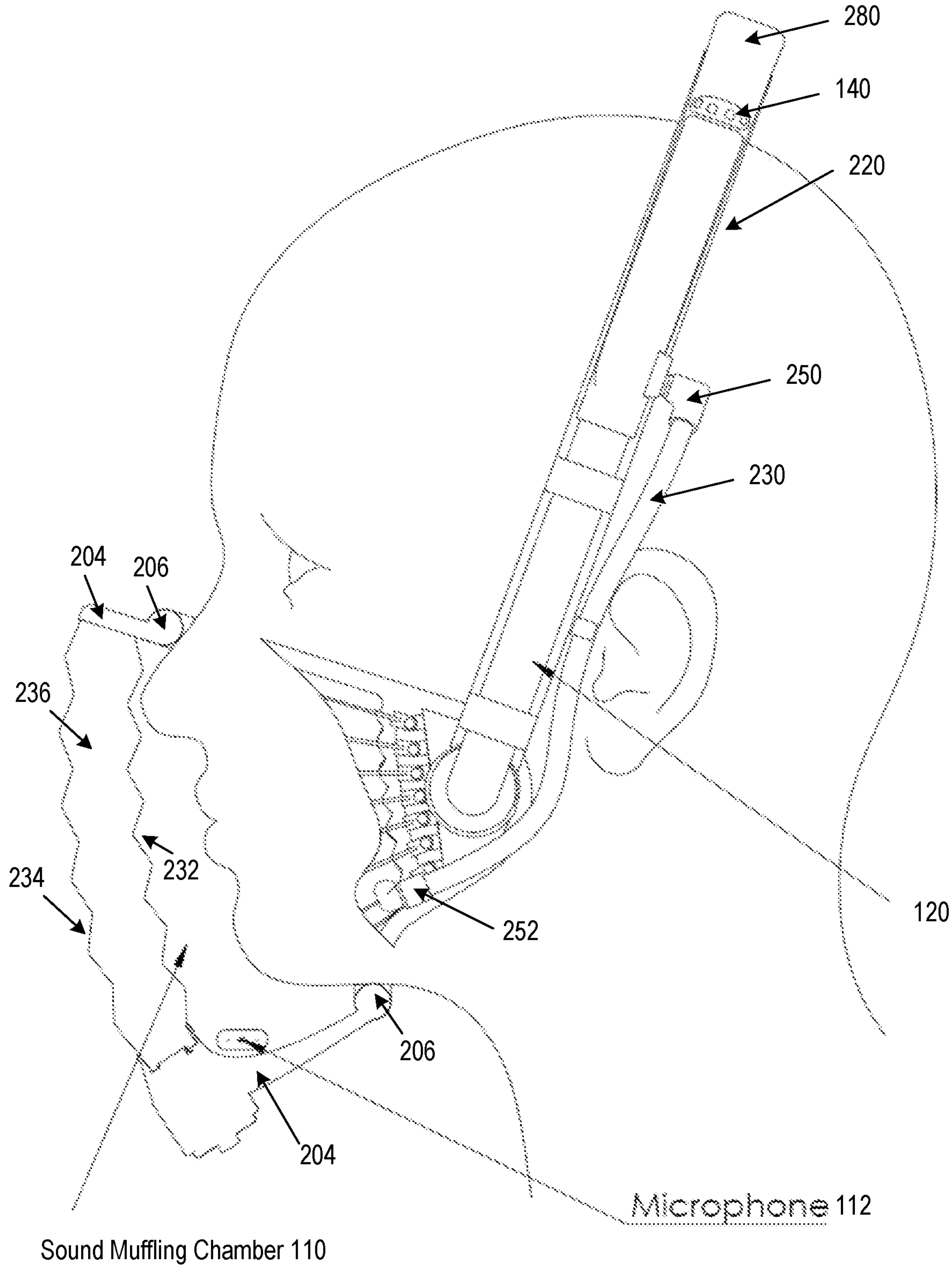

280
140
220
250
230
204
206
236
232
234
120
252
206
204
Microphone 112
Sound Muffling Chamber 110

FIG. 4

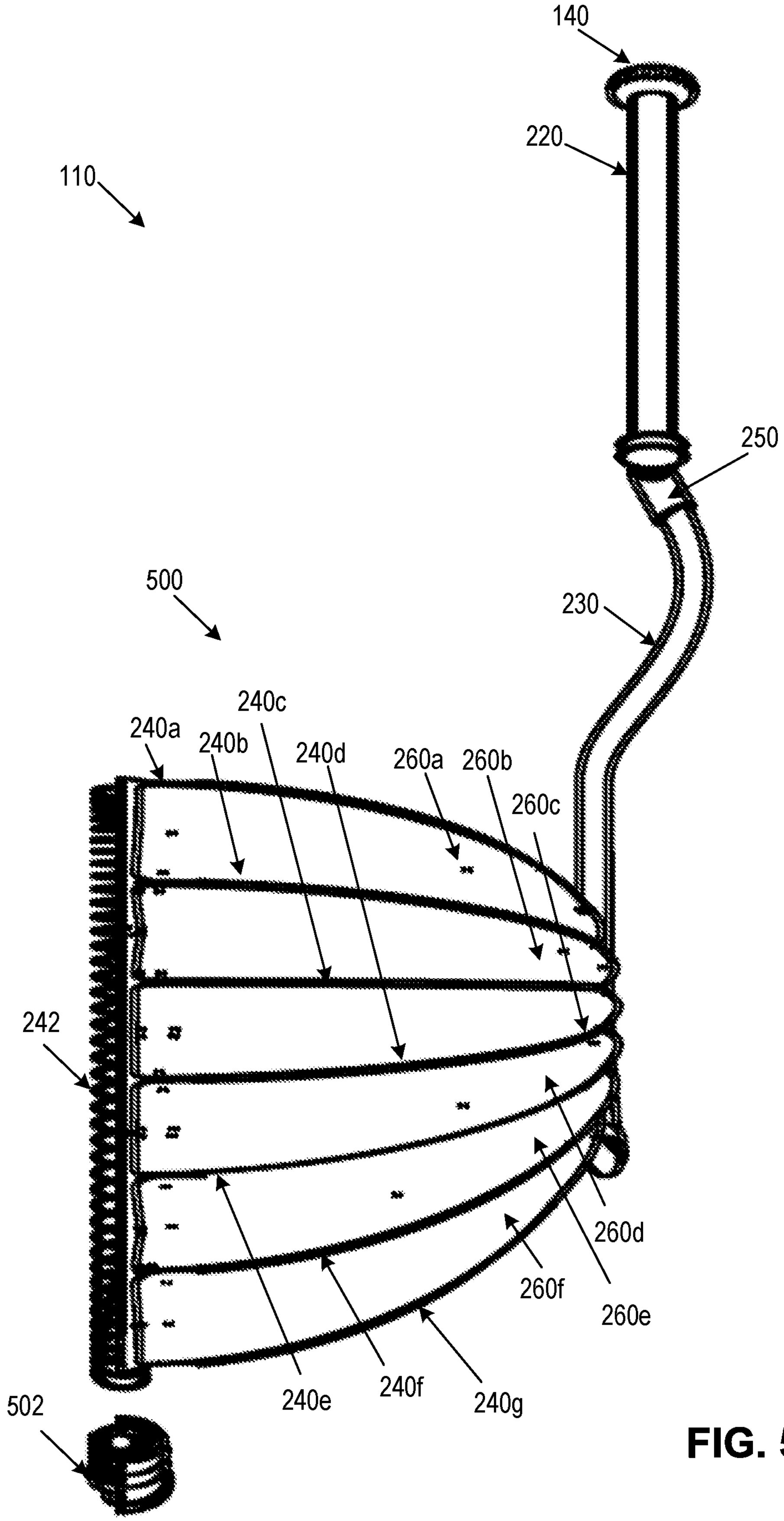

140
220
110
250
500
230
240c
240a
240b
240d
260a
260b
260c
242
260d
260f
260e
240e
240f
240g
502

FIG. 5

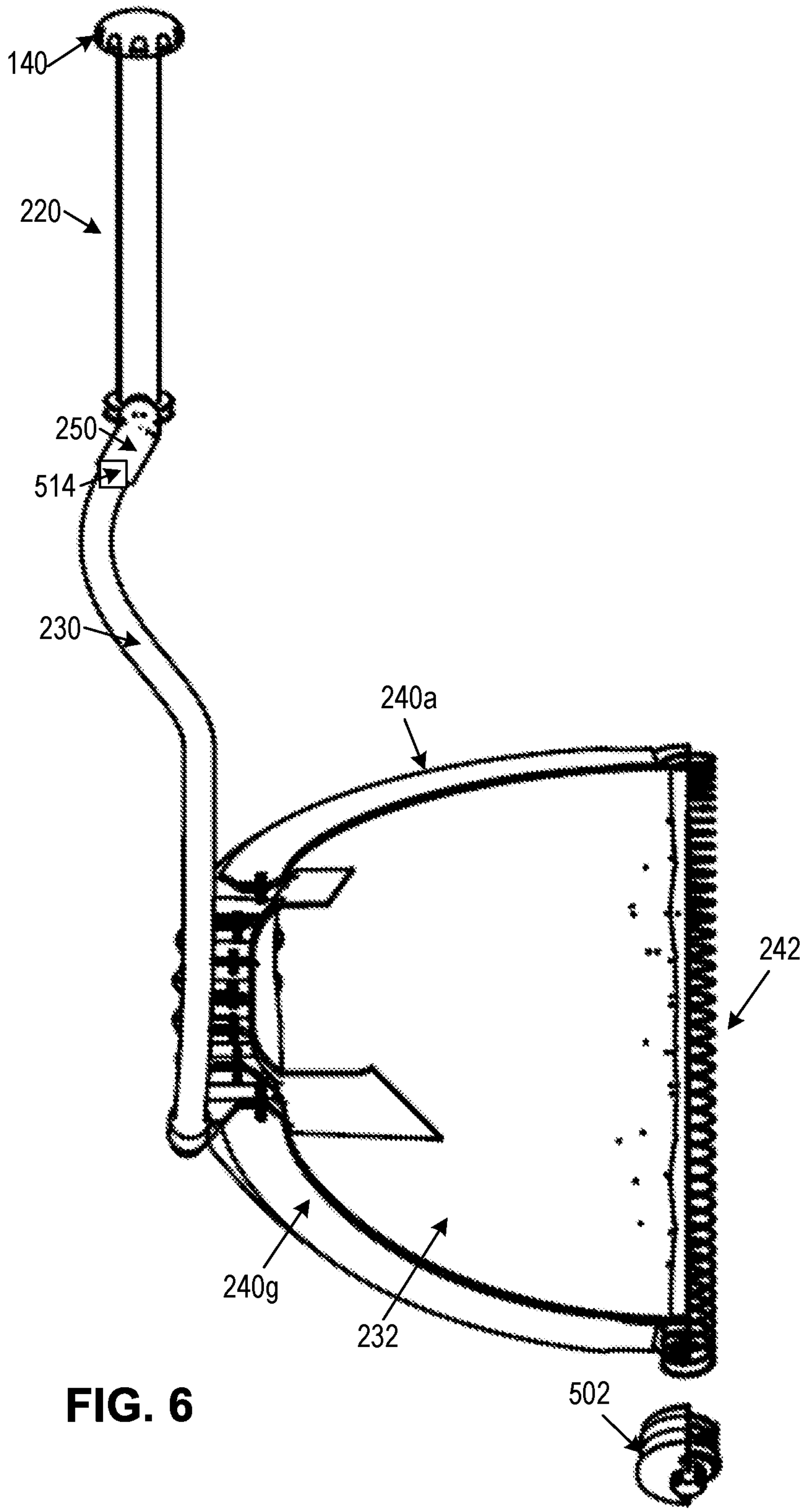


FIG. 6

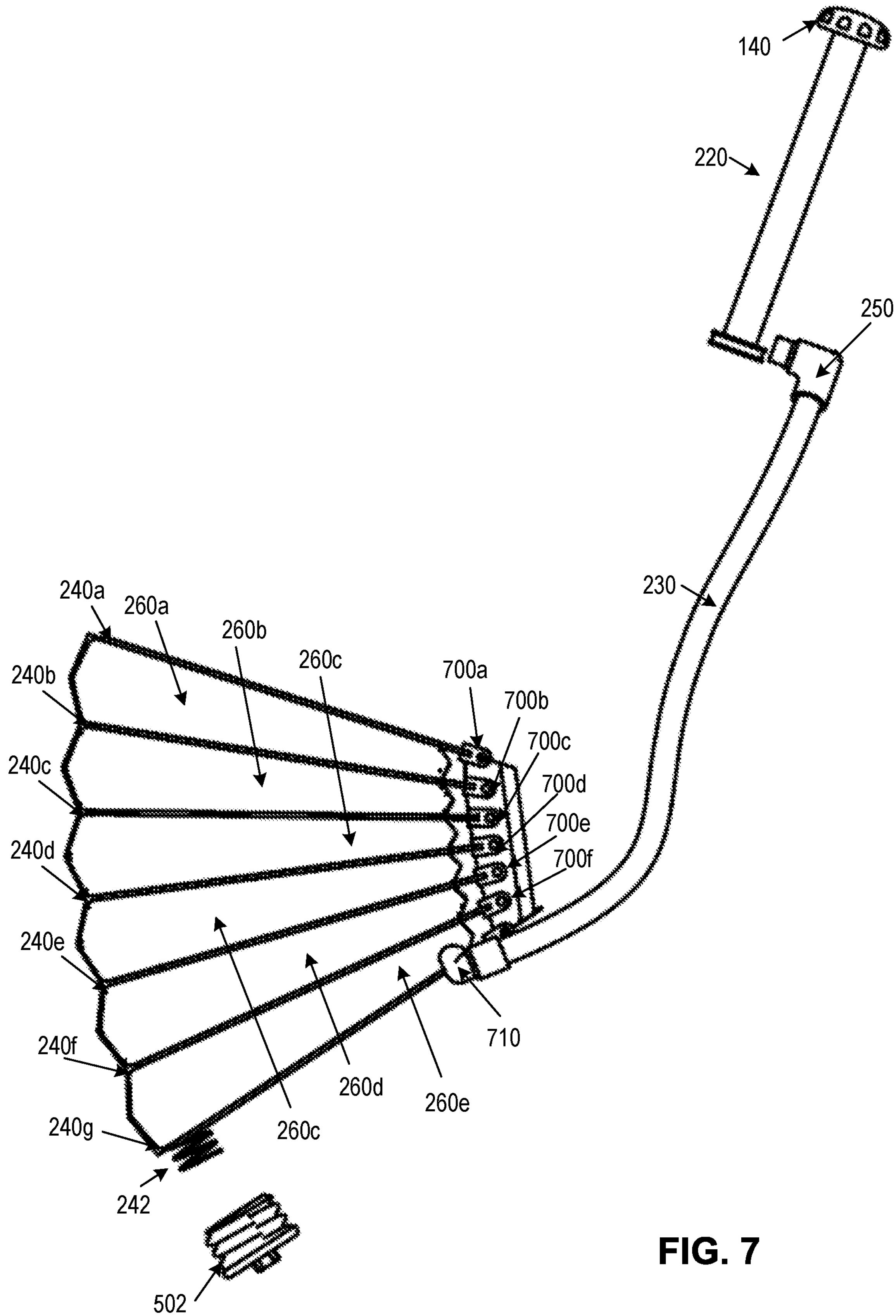

140
220
250
230
240a
260a
260b
260c
700a
700b
700c
700d
700e
700f
240b
240c
240d
240e
240f
240g
710
260d
260e
260c
242
502

FIG. 7

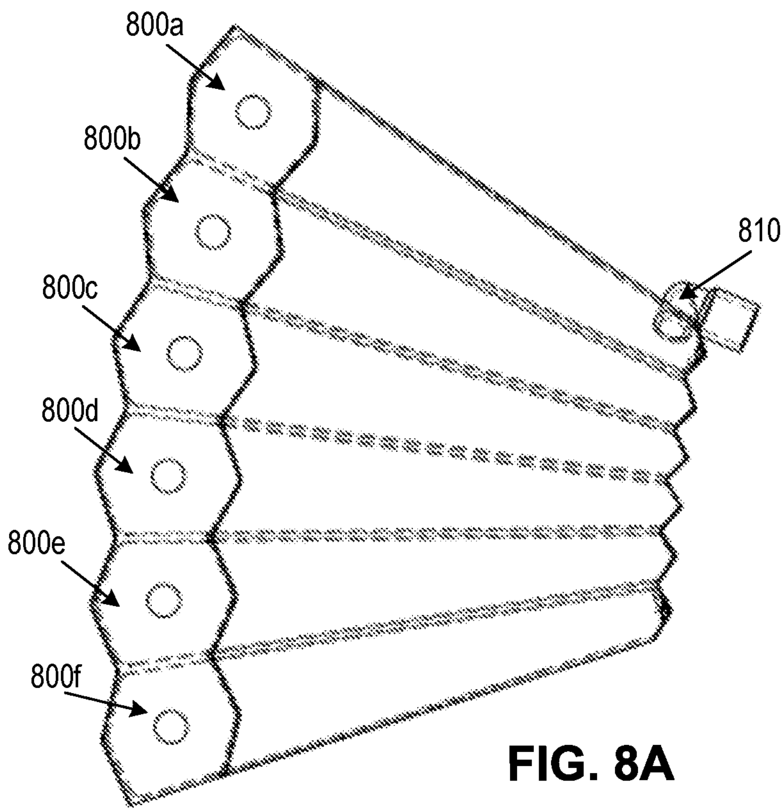

800a
800b
810
800c
800d
800e
800f

FIG. 8A

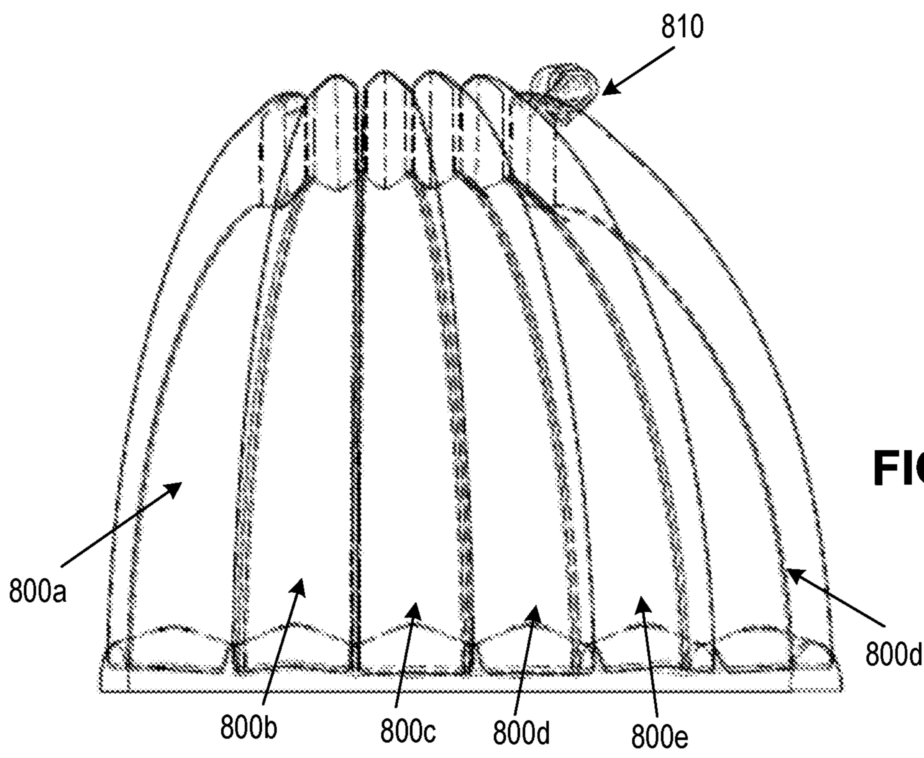

810
800a
800d
800b
800c
800d
800e

FIG. 8B

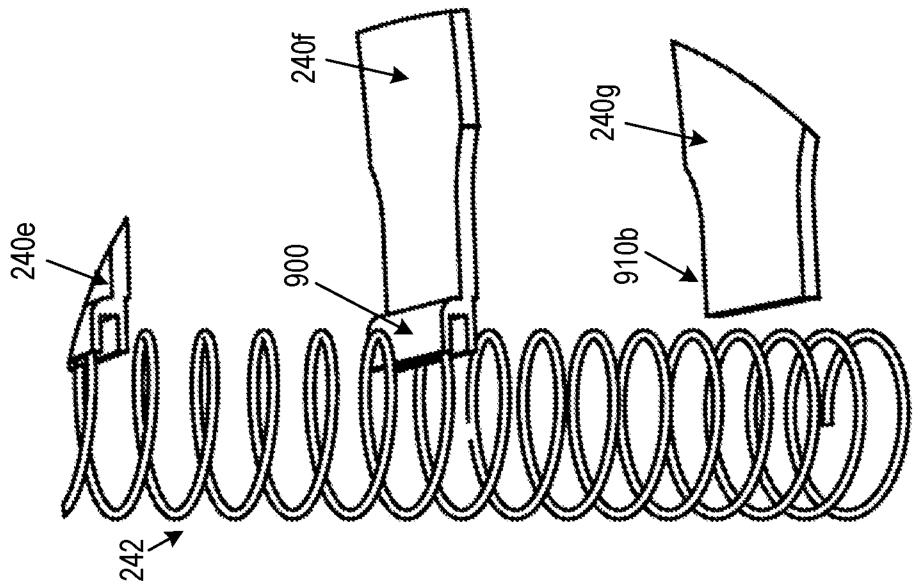

240e
240f
900
240g
910b
242

FIG.9B

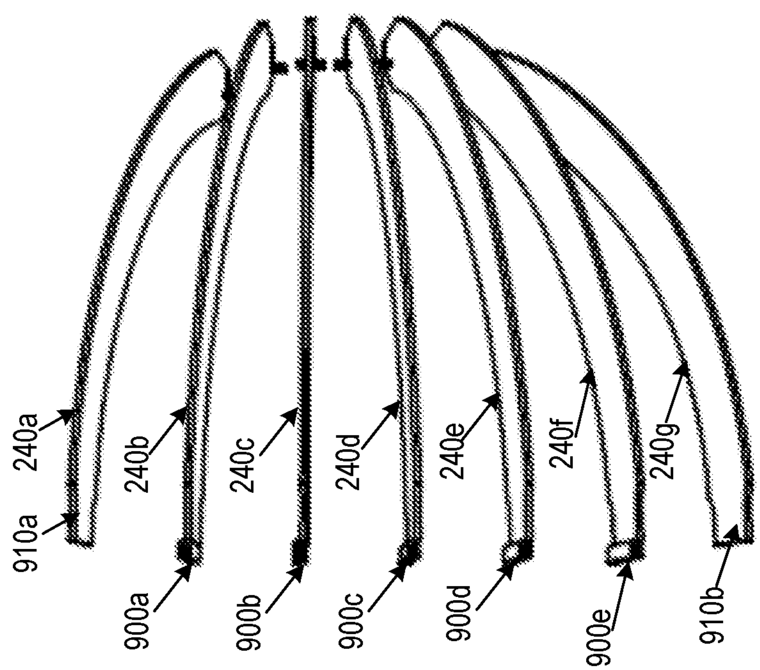

240a
910a
240b
900a
240c
900b
240d
900c
240e
900d
240f
900e
240g
910b

FIG. 9A

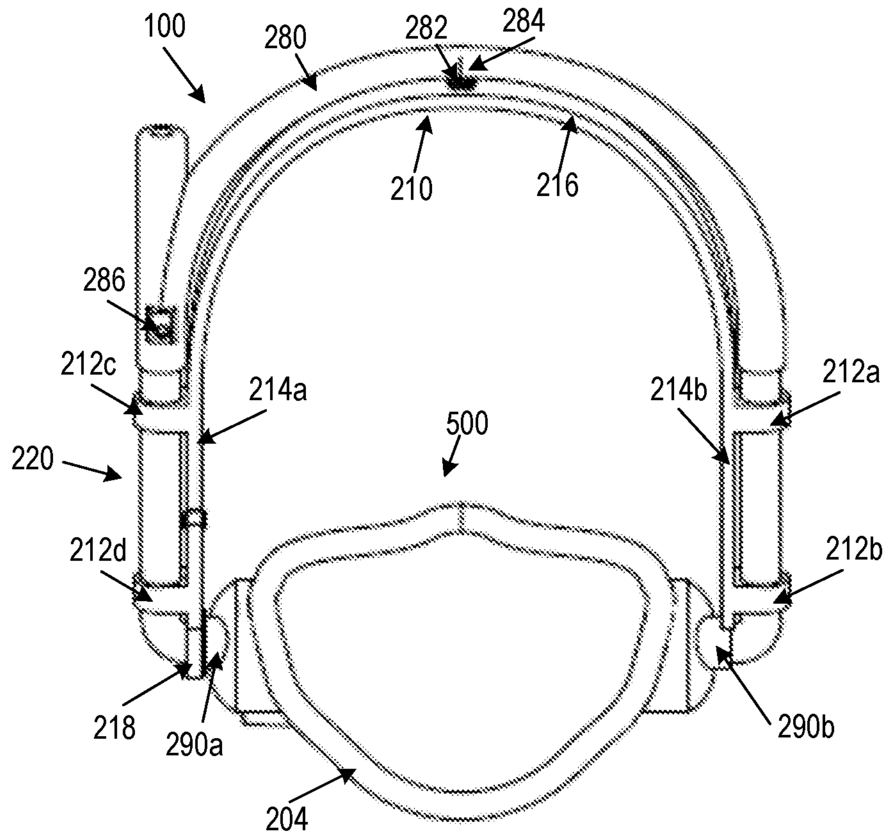


FIG. 10A

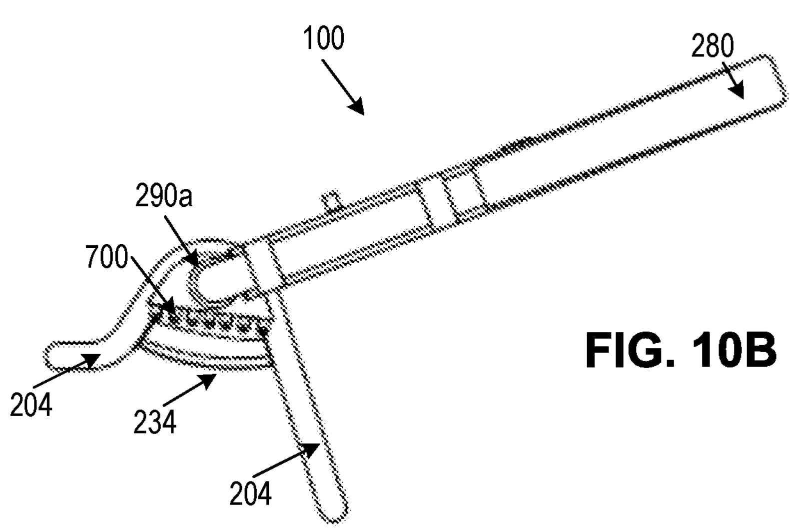


FIG. 10B

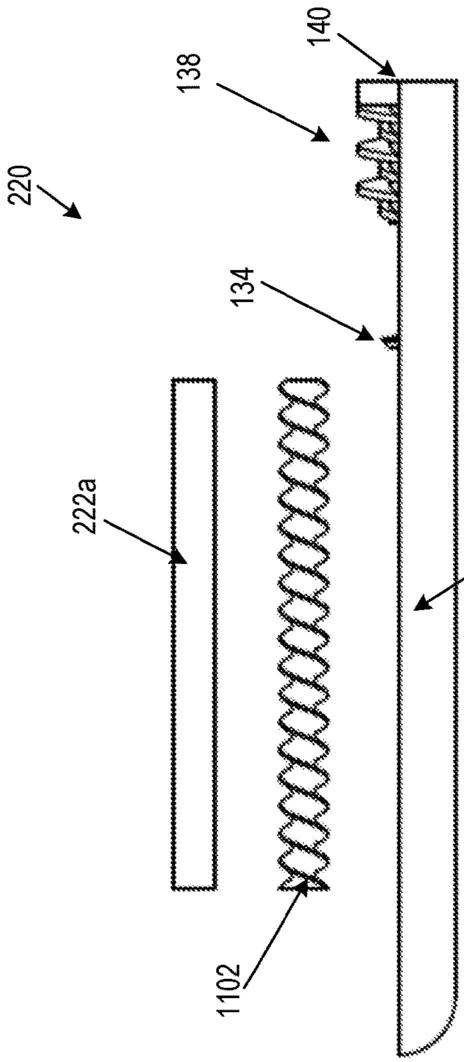


FIG. 11A

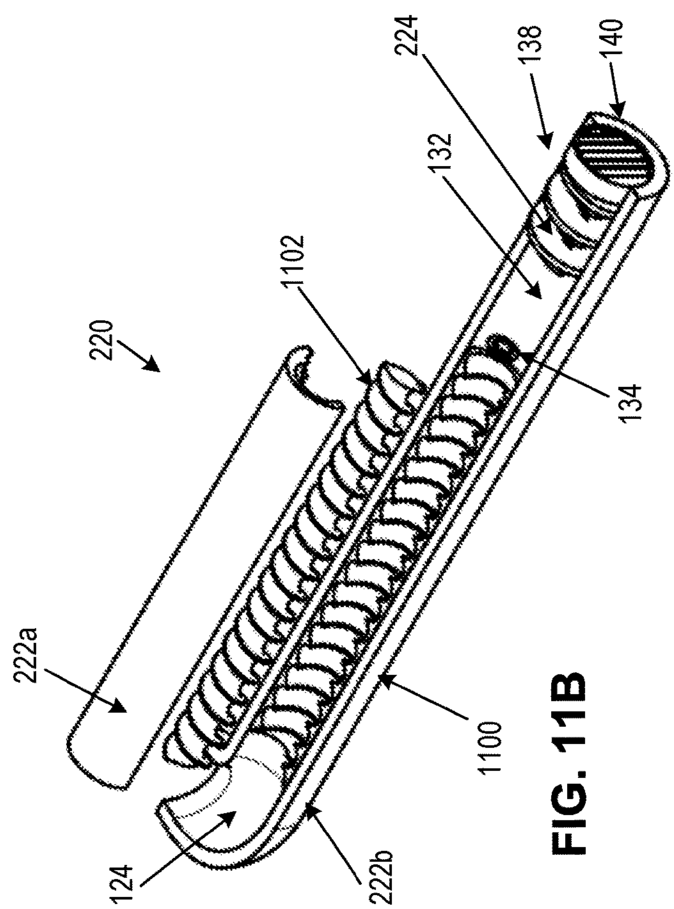


FIG. 11B

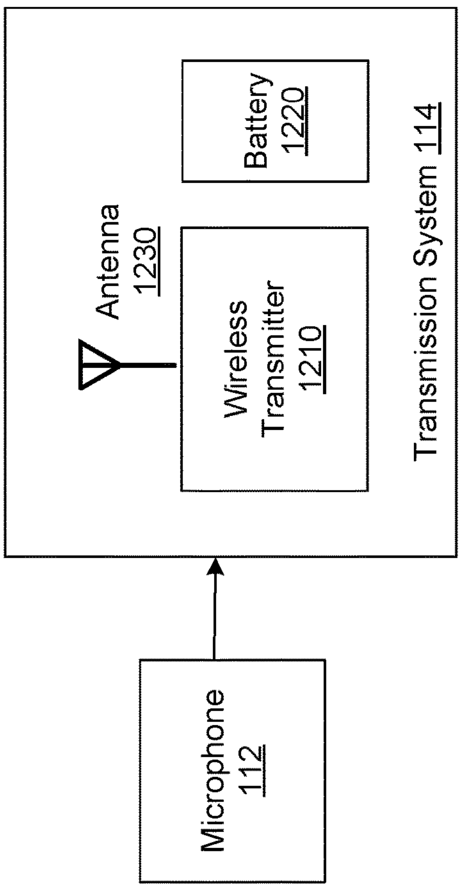

Microphone
112
Antenna
1230
Wireless
Transmitter
1210
Battery
1220
Transmission System 114

FIG. 12

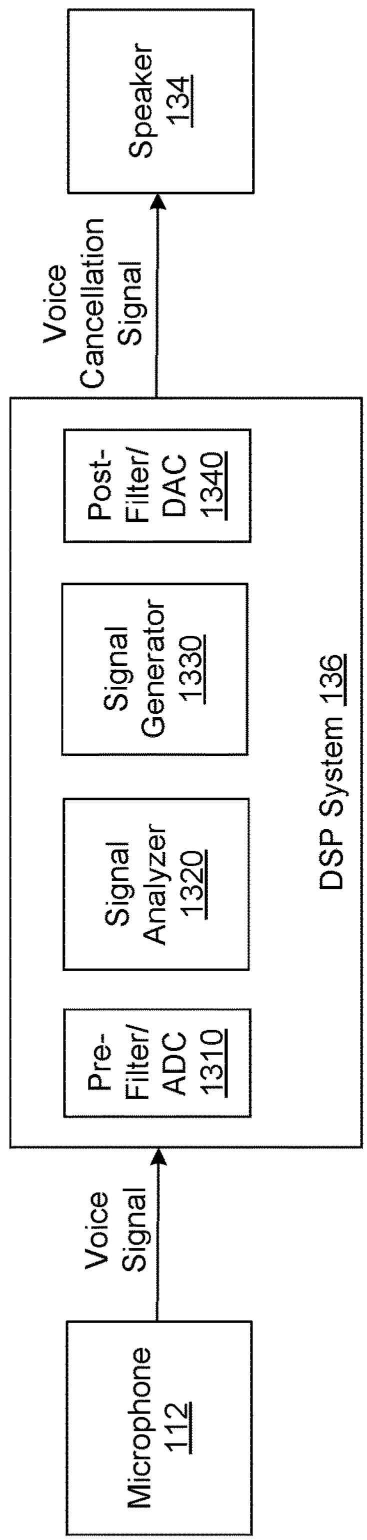

Microphone
112
Voice
Signal
Pre-
Filter/
ADC
1310
Signal
Analyzer
1320
Signal
Generator
1330
Post-
Filter/
DAC
1340
DSP System 136
Voice
Cancellation
Signal
Speaker
134

FIG. 13

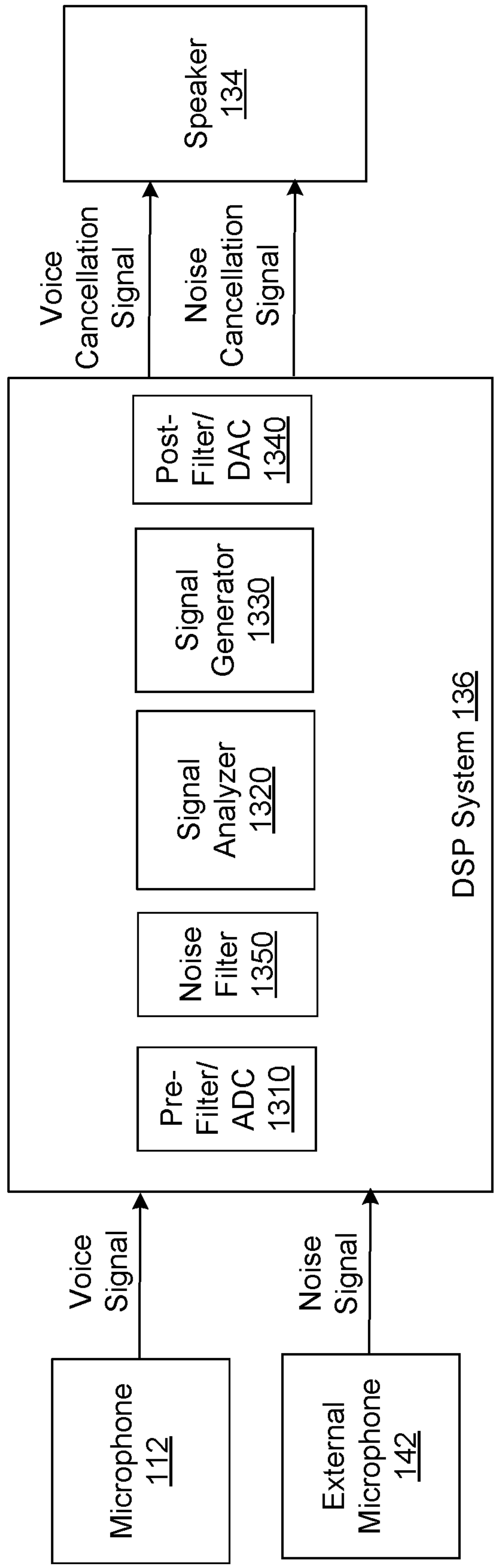

Speaker 134
Voice Cancellation Signal
Noise Cancellation Signal
Post-Filter/ DAC 1340
Signal Generator 1330
Signal Analyzer 1320
Noise Filter 1350
Pre-Filter/ ADC 1310
DSP System 136
Voice Signal
Noise Signal
Microphone 112
External Microphone 142

FIG. 14

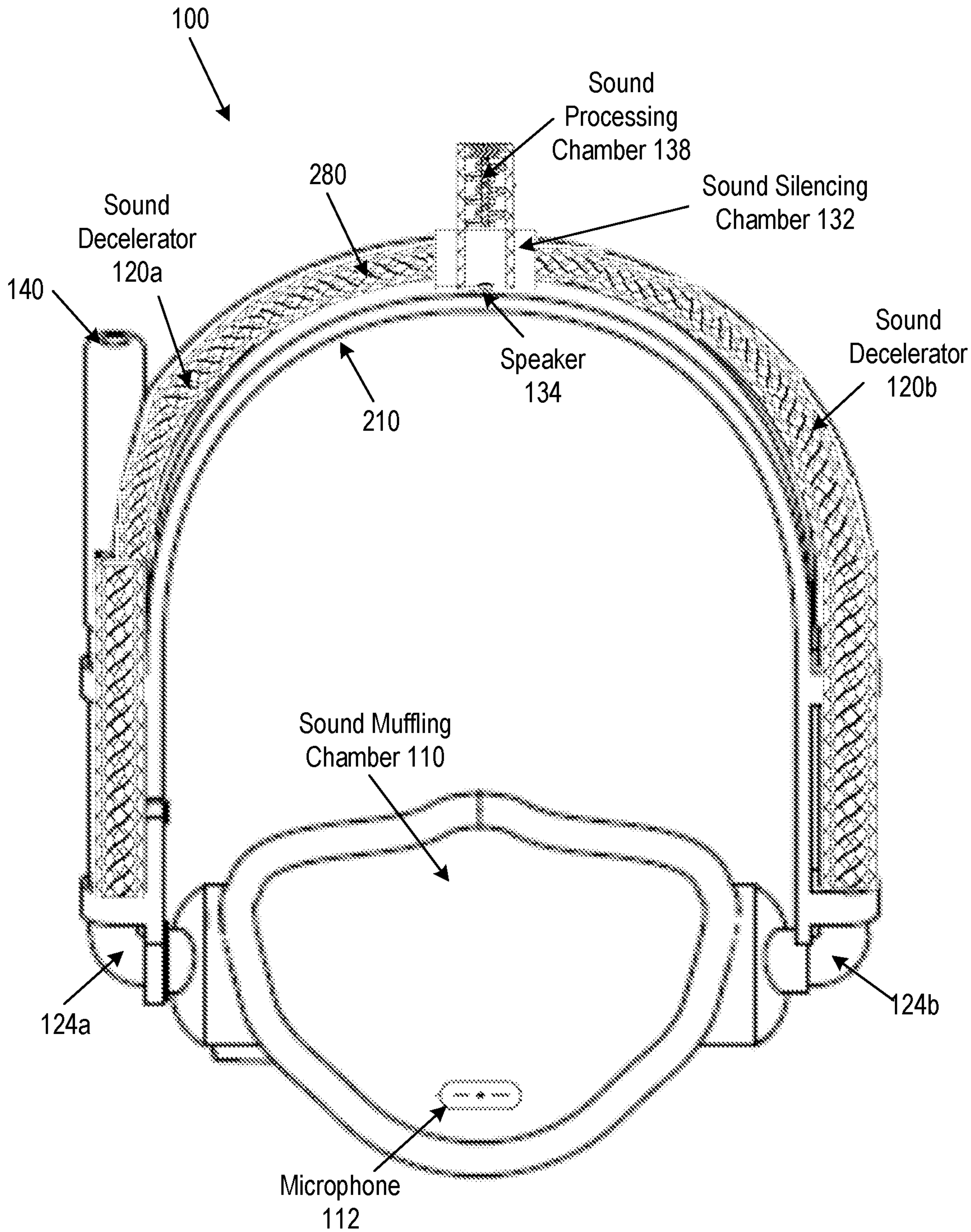

100
Sound Processing Chamber 138
Sound Silencing Chamber 132
280
Sound Decelerator 120a
140
Speaker 134
210
Sound Decelerator 120b
Sound Muffling Chamber 110
124a
124b
Microphone 112

FIG. 15

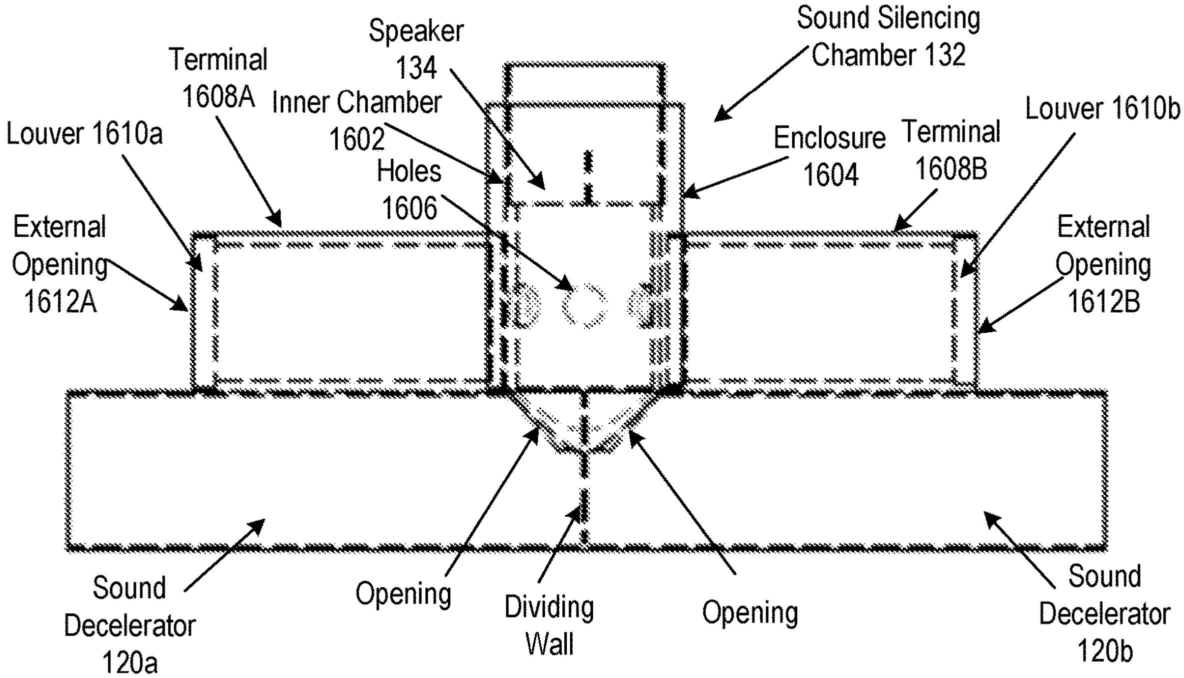


FIG. 16A

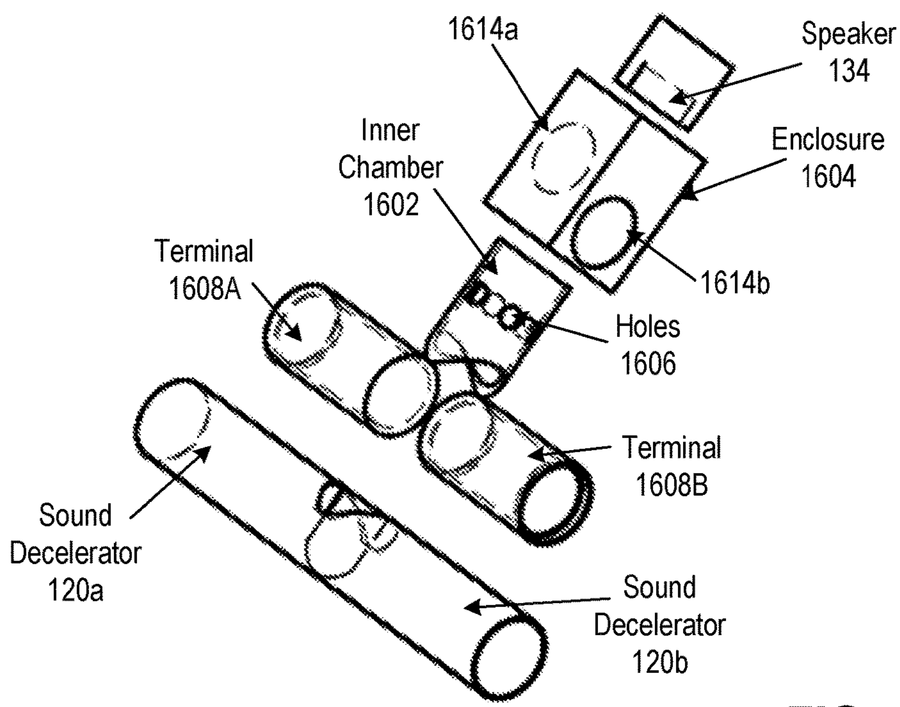


FIG. 16B

SYSTEM AND METHOD FOR A SPEAKING CHAMBER WITH VOICE CANCELLATION

FIELD

This application relates to system and methods for a voice cancellation system and more particularly, to a voice cancellation system including a sound muffling chamber, a sound decelerator, and a sound cancellation system and method to limit the volume and intelligibility of a voice.

BACKGROUND

One of the most important modes of verbal communication is by a phone. The basis of this type of communication is the creation of audible vocal sounds. A user that is talking on a call produces intelligible vocal sounds which are detected by a microphone, e.g., located in the phone. At the same time, the vocal sounds from the user spread in all directions through the surrounding environment. It is this uncontrolled propagation of the vocal sounds that may present problems when the user is in the presence of other people, which occurs quite often. In fact, the presence of other people often cannot be avoided—in open-space offices, in cafes, public transport, or even at home. In these situations, the user may feel extremely uncomfortable knowing that their conversation is not private, and at the same time, the surrounding people may be annoyed by the disturbance of the conversation.

Many attempts have been made to create a device that reduces the propagation of vocal sounds further than the microphone, e.g., located on the user's phone. The underlying principle of these devices is passive voice muffling using an airtight mask that prevents leakage of air into the surrounding environment. The weaknesses with such devices are varied, the chief of which is the requirement of covering the mouth of the user in an air-tight manner, which makes it difficult, if not impossible, for the user to breathe and vocalize. Efforts to improve ventilation capacity of such airtight masks diminishes the effectiveness of the devices. Consequently, such voice muffling devices are not ideal.

Therefore, there is a need for an improved device and method that facilitates private verbal communication over a phone or other user device without causing annoyance to the public. Other and/or alternate advantages will be apparent from the description herein.

SUMMARY

In one aspect, a voice cancellation system includes a sound muffling chamber configured to cover both a nose and mouth of a user, wherein the sound muffling chamber includes soundproof material. At least one microphone is positioned in the sound muffling chamber, wherein the at least one microphone is configured to detect a voice of the user in the sound muffling chamber and generate a voice signal. A sound silencing chamber includes at least one speaker and at least one sound decelerator is fluidly coupled between the sound muffling chamber and the sound silencing chamber, wherein the sound decelerator includes material to increase a traveling time of sound waves from the sound muffling chamber to the sound silencing chamber. A signal processing system is configured to analyze the voice signal and generate a voice cancellation signal, wherein the voice cancellation signal includes one or more frequency components having a same frequency and amplitude but a 180 degrees out of phase from one or more frequency components of the voice signal.

In another aspect, a voice cancellation system includes a sound muffling chamber configured to cover both a nose and mouth of a user, wherein the sound muffling chamber includes soundproof material and at least one microphone positioned in the sound muffling chamber, wherein the at least one microphone is configured to detect voice sound waves of the user in the sound muffling chamber and generate a voice signal. A headband is coupled to the sound muffling chamber, wherein the headband includes a tubular structure configured to extends circumferentially from the sound muffling chamber over a head of the user. A sound silencing chamber positioned near an apex of the headband, wherein the sound silencing chamber includes at least one speaker. At first sound decelerator is positioned in a left side of the tubular structure of the headband, wherein the first sound decelerator is fluidly coupled between a left side of the sound muffling chamber and the sound silencing chamber. A second sound decelerator is in a right side of the tubular structure of the headband, wherein the second sound decelerator is fluidly coupled between a right side of the sound muffling chamber and the sound silencing chamber. A signal processing system is configured to analyze the analog voice signal and generate a digital voice cancellation signal, and the speaker generates analog sound waves in the sound silencing chamber in response to the digital voice cancellation signal.

BRIEF DESCRIPTION OF THE DRAWINGS

A more particular description is included below with reference to specific aspects illustrated in the appended drawings. Understanding that these drawings depict only certain aspects of the disclosure and are not therefore to be considered to be limiting of its scope, the disclosure is described and explained with additional specificity and detail through the use of the accompanying drawings described briefly below.

FIG. **1** illustrates a block diagram of an embodiment of a voice cancellation system including a sound muffling chamber, a sound decelerator, and sound cancellation system.

FIG. **2** illustrates a front perspective view of an embodiment of the voice cancellation system.

FIG. **3** illustrates a front perspective view of an embodiment of the voice cancellation system.

FIG. **4** illustrates a illustrates a side perspective view of an embodiment of the voice cancellation system on a user.

FIG. **5** illustrates a front perspective view of an embodiment of a right half of the sound muffling chamber.

FIG. **6** illustrates a back perspective view of an embodiment of the right half of the sound muffling chamber.

FIG. **7** illustrates a side perspective view of an embodiment of the right half of the sound muffling chamber.

FIGS. **8**A and **8**B illustrate perspective views of an embodiment of the inflatable layers in more detail.

FIGS. **9**A and **9**B illustrate perspective views of an embodiment of the slats and the spring of the sound muffling chamber in more detail.

FIGS. **10**A and **10**B illustrate perspective views of an embodiment of the headband in more detail.

FIGS. **11**A and **11**B illustrate embodiments of the sound egress channel in more detail.

FIG. **12** illustrates a schematic block diagram of an embodiment of the transmission system in more detail.

FIG. **13** illustrates a schematic block diagram of an embodiment of the DSP system in more detail.

FIG. **14** illustrates a schematic block diagram of another embodiment of the DSP system in more detail

FIG. **15** illustrates a perspective view of another embodiment of the voice cancellation system.

FIGS. **16**A and **16**B illustrate views of another embodiment of the sound silencing chamber.

DETAILED DESCRIPTION

The word "exemplary" or "embodiment" is used herein to mean "serving as an example, instance, or illustration." Any implementation or aspect described herein as "exemplary" or as an "embodiment" is not necessarily to be construed as preferred or advantageous over other aspects of the disclosure. Likewise, the term "aspects" does not require that all aspects of the disclosure include the discussed feature, advantage, or mode of operation.

Embodiments will now be described in detail with reference to the accompanying drawings. In the following description, numerous specific details are set forth in order to provide a thorough understanding of the aspects described herein. It will be apparent, however, to one skilled in the art, that these and other aspects may be practiced without some or all of these specific details. In addition, well known steps in a method of a process may be omitted from flow diagrams presented herein in order not to obscure the aspects of the disclosure. Similarly, well known components in a device may be omitted from figures and descriptions thereof presented herein in order not to obscure the aspects of the disclosure.

In an embodiment, a voice cancellation system includes a speaking or sound muffling chamber that enhances a user's privacy and minimizes disturbance to the public. The voice cancellation system includes the following characteristics: 1. The device detects the vocal sounds created by both the nose and the mouth of the user since the clarity of the vocal sounds are lost when either organ is excluded; 2. The device includes a means for the user to inhale and exhale without limitations and without risking sound leakage; 3. The device covers the nose and the mouth in an air-tight manner; 4. The sound-barrier property of the device is robust such that leaking of vocal sounds is limited through the body of the device; 5. The device is sufficiently elastic to accommodate the facial movement and mouth opening and closing without disrupting an air-proof seal; and 6. The device is foldable to permit the user to conveniently carry it. The embodiments described herein include these advantages and/or alternate or additional advantages.

FIG. **1** illustrates a block diagram of an embodiment of a voice cancellation system **100** including a sound muffling chamber **110**, a sound decelerator **120**, and sound cancellation system **130**. The sound muffling chamber **110** is configured to cover a nose and mouth of a user and form an airtight seal against the user's face that prevents leakage of air from the edges of the chamber **110**. The sound muffling chamber **110** further includes a microphone **112** disposed within the chamber **110**, preferably near the user's mouth and/or nose. The microphone **112** is configured to detect the vocal sounds created by both the nose and the mouth of the user within the sound muffling chamber **110**. The microphone **112** converts the vocal sounds to a voice signal and transmits the voice signal to a transmission system **114**. The transmission system **114** may include a wired or wireless transmitter and receiver configured to transmit the voice signal to a user device, such as a phone, watch, laptop, vehicle phone, vehicle sound system, voice recorder, or other processing device. The transmission system **114** may also receive transmissions from the user device, such as audio signals, data, or commands. The transmission system **114** may also transmit any audio signals, such as a voice signal of a caller and transmit the audio signals to a listening device, such as ear buds, speaker, headphone, etc.

The voice signal from the microphone **112** is also transmitted to a digital signal processor (DSP) system **136** for processing. The DSP system **136** receives the analog voice signal from the microphone **112** and generates a digital voice cancellation signal. The DSP system **136** analyzes the analog voice signal to determine a plurality of frequency components and determines an amplitude and phase of the plurality of frequency components. The DSP system **136** then generates a digital voice cancellation signal including complementary frequency components that are 180 degrees out of phase from the frequency components of the analog voice signal.

A sound outlet **122** is formed in an airtight manner in the sound muffling chamber **110**. A connector tube **124** is coupled between the sound outlet **122** and the sound decelerator **120**. The sound decelerator **120** includes one or more materials configured to slow a travel time of the sound waves, e.g., increase a traveling time of the sound waves from the sound muffling chamber **110** to a sound silencing chamber **132**. The sound decelerator **120** provides time for the DSP system **136** to generate the voice cancellation signal.

In use, vocal sound waves emanate from the sound outlet **122**, e.g., such as from the user's voice, and are slowed through the sound decelerator **120** and then guided into the sound silencing chamber **132**. The sound silencing chamber **132** includes a speaker **134** that emits analog out of phase sound waves in response to the digital voice cancellation signal from the DSP system **136**. In the sound silencing chamber, the out of phase sound waves from the speaker **134** superimpose on and destructively interfere with the native vocal sound waves, thereby substantially decreasing the vocal sound waves or even completely eliminating some or all the vocal sound waves. The end result is a significant reduction in loudness and intelligibility of the user's voice to the surrounding environment.

In an embodiment, a terminal conduit **138** extends from the sound silencing chamber **132** to the external environment and includes sound wave mixing and/or sound decelerator materials and a porous outlet cover. For example, the terminal conduit **138** may include a tortuous structure and/or porous sound retarding materials to help prevent transmission of external noise to the sound muffling chamber **110**. The air outlet **140** allows the user to inhale and exhale without limitations and without risking leakage of intelligible speech. An external microphone **142** may also be disposed on an external wall of and/or near or within the air outlet **140** to detect external noise and/or sounds emitted from the terminal conduit **138**. The detected noises and/or sounds may be transmitted to the DSP system **136** to generate a noise cancellation signal to further dampen the sounds emanating from the voice cancellation system **100**.

The sound decelerator **120** includes a tortuous sound conducting conduit that is filled with porous materials. The sound decelerator **120** is between 4.5 cm to 20 cm long and made of one or more air-tight materials, such as plastics, metals, or wood. The proximal end of the sound decelerator fluidly connects to the sound muffling chamber and the distal end to the sound silencing chamber. The tortuous configuration of the sound conducting conduit may be of convoluted, zigzag, helical, spiral, wavy, labyrinthine pattern. The luminal wall of the sound conducting conduit may be of variable roughness. These features of the sound conducting conduit serve to slow the sound transmission by increasing the sound transmission distance and by elevating sound flow resistance.

The sound propagation speed in the sound conducting conduit is further modulated by the presence of porous material in the conduit lumen. Sound transmission through a porous material is principally determined by the material's density, cross-sectional area, pore tortuosity, and length of the medium. The selected material should be harmless to humans when inhaled, be resistant to moisture and microbial growth, and allow adequate air exchange. Examples of suitable filling materials include neoprene foam, polyethylene foam, graphene foam, polyolefin foam, expanded polystyrene, graphite foam, charcoal foam, and polystyrene hard foam.

Through the use of such an acoustic conduit the speed of sound transmission is sufficiently reduced, thereby providing additional time, e.g., at least the time necessary for the out of phase sound waves to be produced by the speaker **134**. The slowed transmission of the vocal sound waves of the user through the sound decelerator **120**, then, makes it possible for the vocal sound waves and the out of phase sound waves from the speaker **134** to be present simultaneously at the sound silencing chamber **132**. When excess time is provided by the sound decelerator **120**, the DSP system **136** may delay transmitting the voice cancellation signal or otherwise synchronize the generation of the anti-phase sound waves to the arrival of the voice sound waves.

Disposed at both ends of the sound decelerator **120** is sound absorbing material. Sound absorbing materials that meet the above specification include Neoprene foam, polyethylene foam, graphene foam, polyolefin foam, expanded polystyrene, graphite foam, charcoal foam, polystyrene hard foam. The presence of the sound absorbing material helps to absorb any reflected sounds at the proximal opening of the sound decelerator **120** and further slow the forward sound transmission. The presence of the sound absorbing material at the distal end of the sound decelerator **120** serves to further retard the speed of the sound transmission and helps to reduce the retrograde transmission of sounds, whether it be external or residual sounds post destructive interference. The internal surface of the sound wave conducting tubes may be further lined with materials that may increase the sound flow resistance, such as fabric, granules, or other suitable material. The distal end of the sound decelerator **120** is configured to couple with the sound silencing chamber **132**. The voice cancellation system **100** thus muffles the voice of the user and ensures unintelligibility of the conversation of the user to the external environment. In addition, the voice cancellation system **100** provides sufficient airflow to the user while covering both the nose and mouth of the user. FIGS. **2** and **3** illustrate perspective views of an embodiment of the voice cancellation system **100**, wherein FIG. **2** illustrates a front perspective view and FIG. **3** illustrates a back perspective view. Referring to both FIGS. **2-3**, the voice cancellation system **100** is configured to be worn on the head of a user with the sound muffling chamber **110** fitted over the mouth and nose. Including the nose within the sound muffling chamber **110** is of paramount importance for the user's voice to sound normal. When the nose is excluded, the user's voice may be perceived as being "nasal" and can be annoying to the listener.

In one embodiment, the sound muffling chamber **110** includes a left portion and a right portion that intersect at a centrally located spring **242**. In FIGS. **2** and **3**, only the left portion (e.g., the portion worn on a left side of the user's face) is shown to better illustrate the structure of the sound muffling chamber **110**. The overall shape of the sound muffling chamber **110** is spherical in the longitudinal axis and parabolic in the transverse axis. This configuration permits sufficient space in front of the user's nose and the mouth for the comfort of the user.

In contrast to the previous art, the sound muffling chamber **110** does not have a "vent" that will cause leakage of the user's voice. In an embodiment, the sound muffling chamber **110** has no vent or opening that directly communicates with the ambient atmosphere. Instead, on at least one side of the sound muffling chamber **110**, the sound outlet **122** fluidly connects with an elbow-shaped connector tube **124**, to a proximal end of a sound egress channel **220**. An opposing, distal end of the sound egress channel **220** forms the sound outlet port **140**. Between the proximal and distal ends, the sound egress channel **220**, in one example, includes, e.g., the sound decelerator **120**, the silencing chamber **132**, and/or the terminal conduit **138**. Therefore, in this example, the air to and from the sound muffling chamber **110** must flow through the sound decelerator **120**, sound silencing chamber **132** and terminal conduit **138**.

The sound egress channel **220** is supported by an inner headband **210** that extends circumferentially around the top of the head. The inner headband **210** may include one or more brackets **212***a-d* that hold the sound egress channel **220** and/or other components of the voice cancellation system **100**. A tubular, outer headband **280** may be attached to the inner headband **210** and/or the sound silencing chamber **132** and is configured to fit circumferentially around the headband **210**.

The sound muffling chamber **110** includes an external wall **234** and an internal wall **232** that help form an airtight enclosure that provides sound insulation. The external wall **234** and internal wall **232** may each include one or more layers of soundproofing materials or insulation. In an embodiment, the sound muffling chamber **110** may include one or more inflatable layers, as described in more detail hereinbelow. The voice cancellation system **100** may further include an air inlet pipe **230** that provides a fluid connection to the interior space of the sound muffling chamber **110** for inflation and deflation of the one or more inflatable layers. These inflatable layers and the spring **242** enable folding of the sound muffling chamber **110** for easier carrying of the voice cancellation system **100** when not in use.

The lateral body of the sound muffling chamber **110** includes an opening that receives the sound egress channel **220**. The connection is made rotatable and sound insulated by means of a threaded coupling. The lumen of the sound sound egress channel **220**, e.g., including the sound decelerator **120** and sound silencing chamber **132**, is thus in fluid connection with the mask chamber.

The transmission system **114** provides a wireless or wired connection between the voice cancellation system **100** and the user's device and may be disposed in the inner headband **210** or in an isolated segment of the outer headband **280**. The transmission system **114** may also provide a wireless or wired connection to one or more listening devices, **208***a,b*, such as speakers, earbuds, headphones, or other devices, that are attached to or integrated with the voice cancellation system **100**.

FIG. **4** illustrates a side perspective view of an embodiment of the voice cancellation system **100** on a user. The rim **204** surrounds the sound muffling chamber **110** circumferentially and is made of a rigid material, such as a plastic and/or metal, and provides structural stability to the sound muffling chamber **110**. When worn, an inferior portion of the rim **206** is designed to run along the mandible, and the left and right side of the rim **204** extends on the left and right side of the cheeks, respectively. The upper portion of the rim **204** runs along the middle of the cheek laterally and over the bridge of the nose medially.

The inner rim **206** of the sound muffling chamber **110** is ergonomically contoured to fit naturally over the lower face and the nose and is padded with a soft material to enhance the comfort for the user. The padding material is selected to optimize the skin contact, hence the sound proofing of the sound muffling chamber **110**. The inner rim **206** with the padding material is sufficiently elastic to accommodate the facial movement and mouth opening and closing without disrupting an air-proof seal to the skin. For the remainder of the sound muffling chamber **110**, the contour of the mask can in general follow the contour of the face. In fact, it is advantageous in the periphery circumferentially to create air proof contact so that there's no speech or voice sounds leaked or ingress of external noise.

The air inlet pipe **230** is attached to the inner headband **210** and/or outer headband **280** and includes, at an inferior end, an inlet port **252** that provides a fluid connection to the interior space **236** of the sound muffling chamber **110**. At a superior end, the air inlet pipe **230** includes an air inlet valve **250** that may be opened and closed for inflation and deflation of the one or more inflatable layers **260** of the sound muffling chamber **110**. A pump or other air source may be attached to the air inlet valve **250** to insert air into the interior space **236** of the sound muffling chamber **110**. In an open position, the air inlet valve **250** fluidly couples the air inlet pipe **230** to an air source and in a closed position, fluidly closes or decouples the air inlet pipe from the air source.

FIGS. **5**-**7** illustrate the inflatable layers **260***a*-*f* of the sound muffling chamber **110** in more detail, wherein FIG. **5** illustrates a front perspective view of a right half of the sound muffling chamber **110**, FIG. **6** illustrates a back perspective view of the right half of the sound muffling chamber **110**, and FIG. **7** illustrates a side perspective view of the right half of the sound muffling chamber **110**. In an embodiment, the sound muffling chamber **110** includes a plurality of inflatable layers **260***a*-*f*, a plurality of slats **240***a*-*g*, and a central spring **242**. The overall shape of the sound muffling chamber **110** is created by the plurality of slats **240***a*-*g* that extend the width of the sound muffling chamber **110**. The slats **240***a*-*g* provide structural support to the body **500** of the sound muffling chamber **110** and run in the transverse axis from a left side of the rim **204** to the central spring **242** and from a right side of the rim **204** to the central spring **242**. Each of the inflatable layers **260***a*-*f* is positioned between and supported by a different pair of slats **240***a*-*g*. In this example, the sound muffling chamber **110** includes six inflatable layers **260***a*-*f* and seven slats **240***a*-*g*. However, in other exemplary embodiments, the sound muffling chamber **110** may include more or less inflatable layers **260***a*-*f* and/or slats **240***a*-*g*.

The center section of the sound muffling chamber **110** comprises a vertically oriented compression spring **242** that extends the whole vertical length of the sound muffling chamber **110** and is centrally positioned to the slats **240***a*-*g*. The superior end of the spring **242** is secured to a top plate by a locking member and the inferior end of the spring **242** is secured to a bottom plate by a locking member **502**. The locking member **502** may be engaged or disengaged to lock and unlock the spring **242**. When in an unlocked state, the spring **242** is vertically compressed and so compresses the plurality of slats **240***a*-*g* together. The plurality of inflatable layers **260***a*-*f* are deflated and folded between the plurality of slats **240***a*-*g*. When locked in an extended state, the spring **242** is expanded and pushes the plurality of slats **240***a*-*g* apart. The plurality of inflatable layers **260***a*-*f* may be inflated to extend between the plurality of slats.

To inflate the plurality of layers **260***a*-*f*, the air inlet valve **250** of the air inlet pipe **230** is opened. A pump or other mechanism may be connected to the air inlet valve **250** and used to pump air into the air inlet pipe **230**. The air flows, e.g., from an air pump or other source, from the air inlet pipe **230** into the inlet port **252** that provides a fluid connection to the plurality of inflatable layers **260***a*-*f* in the sound muffling chamber **110**. The inflatable layers **260***a*-*n* expand in response to the pressure of the pumped air. A pressure gauge **514** may be located, e.g., on the air inlet pipe **230** or air inlet valve **250**, and used to determine a pressure in the inflatable layers **260***a*-*f*. The inflatable layers **260***a*-*f* may be inflated to a predetermined pressure or pressure range. To maintain the proper air pressure in the inflatable layers **260***a*-*f*, the elements of the body **500** of the sound muffling chamber **110** are assembled hermetically. When inflated, the material and thickness of the plurality of inflatable layers **260***a*-*n* help to provide an effective sound barrier.

For deflation, the air inlet valve **250** is opened, and the central spring **242** is unlocked such that the slats **240***a*-*g* are compressed toward each other. A lock mechanism (not shown) may be implemented to engage and lock the superior and inferior ends of the central spring **242** into a compressed state. This compression of the central spring **242** also compresses the inflatable layers **260***a*-*n* and forces the egress of air from the air inlet pipe **230**. As air is released, the inflatable layers **260***a*-*n* fold inside the plurality of slats **240***a*-*g*. The size of the body **500** of the sound muffling chamber **110** is thus decreased, and so the voice cancellation system **100** is more convenient to carry, e.g., around the neck of the user or in a backpack.

The longitudinally expandable property of the sound muffling chamber **110** serves another important function. It allows the user to easily open and close their mouth when talking without dislodging the sound muffling chamber **110** from its proper position. Without this expandable property, the position of the sound muffling chamber **110** may be forced out of alignment to accommodate the closing and opening of the mouth. With such an unstable contact between the mask and the face, there is a strong possibility of sound leaking, which is less than ideal. Thus, the sound muffling chamber **110** in this embodiment is expandable in the longitudinal axis at least by the same magnitude as the mouth opening. This expansion allows the contact between the sound muffling chamber **110** and the face to remain properly aligned and the air-proof property can be maintained during speaking. In addition, the skin-contacting inner rim **206** is lined with soft non-porous material to effect an airtight sealing.

As shown in FIG. **7**, at the lateral ends, the slats **240***a*-*n* are attached to the lateral rim **204** via coupling members **700***a*-*f*. The coupling members **700***a*-*f* are swivably attached to the lateral rim via rivets. This connection enables the slats **240***a*-*n* to swivel during inflation and deflation of the inflatable layers **260***a*-*n* and during movement of the user's mouth.

The sound muffling chamber **110** may also include an exterior wall **234** and an interior wall **232** that enclose the slats **240***a*-*g* and the inflatable layers **260***a*-*f* and form part of the air-tight enclosure of the sound muffling chamber **110**. The exterior wall **234** and the interior wall **232** may comprise multiple layers of sound-absorbing material, such as fabric or foam made from natural and synthetic materials, intermixed with a non-porous sound reflecting layer that may be derived from polymers, silicone, or rubber. The interior wall **232** of the sound muffling chamber **110** may be lined or coated with a sound-absorbing material to create an anechoic chamber. For example, the interior wall **232** may include a sound absorbing layer or coat, such as acoustic paint, fabric, or fibers. The outermost wall **234** of the inflatable layers **260***a-n* may be further reinforced with a decorative layer or sound barrier materials. Both the inner and outer walls of the sound muffling chamber **110** span the entire height of the mask body and are hermetically affixed/bonded to the inner surface and outer surface of the slats **240***a-n*, respectively.

FIGS. **8**A and **8**B illustrate perspective views of an embodiment of the inflatable layers **260***a-n* in more detail, wherein FIG. **8**A illustrates a bottom perspective view and FIG. **8**B illustrates a front perspective view of the inflatable layers **260***a-n*. The sound barrier in the sound muffling chamber **110** is created by the multiple inflatable layers **260***a-n* of sound blocking materials. In an embodiment, the inflatable layers **260***a-n* comprise longitudinally expandable, transversely oriented, honeycomb-shaped air cells (honeycomb cells) **800***a-f* that span the entire horizontal width of the body **500** of the sound muffling chamber **110**. The height of each honeycomb cell **800***a-f* tapers from the central section to the lateral rim **204** of the sound muffling chamber **110**. The height of a honeycomb cell **800***a-f* at the central portion may range between 10 mm to 30 mm and the height of the honeycomb cell **800***a-f* laterally may range between 2 mm to 10 mm. Each of the interposing inflatable layers **206***a-n* measures 5 mm to 15 mm in the anterior to posterior direction. Honeycomb cells **800***a-f* taper in the medial to lateral direction where the lateral dimension is ⅓ to ½ of the medial dimension. The honeycomb shaped cells **800***a-f* include openings such that the inflatable layers **260***a-f* are fluidly coupled for inflation and deflation.

The honeycomb cells **800***a-f* may be in the inflated state or deflated state. In the inflated state, the honeycomb cells in the inflatable layers **206***a-n* expand the cell space, thereby enhancing the sound barrier capability. The cross section of a honeycomb cell **800***a-f* takes on an irregular hexagonal shape with two opposing faces being much longer than the other four faces. These two faces form the superior and inferior surface of an inflatable honeycomb cell. By means of rivets, an adhesive, a plurality of screws, or other attachment means, one of the two longer faces of each honeycomb cell **800***a-f* affixes to the superior face of a lower, contiguous slat **240***a-f* and the opposing face affixes to the inferior face of an upper, contiguous slat **240***a-f*. The posterior side of the honeycomb cells **800***a-f* are hermetically attached to the inner wall **232** of the sound muffling chamber **110** by means of rivets, an adhesive, a plurality of screws, or other attachment means. Utilizing a similar means, the anterior surface of the honeycomb cell **800***a-f* are hermetically attached to the outer wall **234** of the sound muffling chamber **110**.

The outer **234** and inner wall **232** and honeycomb cells **800***a-f* form a triple-layered structure. The honeycomb cells **800***a-f* may comprise thin, non-porous, thermoplastic film(s), such as high density polyethylene (HDPE), polypropylene(PP), polycarbonate (PC), polyvinyl chloride (PVC), polyethylene terephthalate (PET), polyvinylidene chloride (PVDC), and polyamide (PA), poly(vinylidene chloride) (PVDC), poly(vinyl alcohol) (PVOH), or other suitable material. One of the main functions of the honeycomb cells **800***a-f* is to block the transmission of the user's voice. The outer **234** and inner wall **232** of the honeycomb cells **800***a-f* include sound-absorbing and sound-nonreflective, porous or non-porous fabric, foam, or a perforated film layer.

Each of the honeycomb cells **800***a-f* is made with creases on all six edges to facilitate a folding assembly. At the lateral end, each honeycomb cell **800***a-f* ends in a hexagonal blind pouch with creases created thereof. Creases are on the central layer of both the inner and outer sound barrier structure before the flanking layers are bonded. The created creases are precisely designed to align with the honeycomb creases. Creases may or may not be created on the flanking layer. Once creases are created, the central layer and the flanking layers are bonded together. The bonding material remains elastic after it cures. The same bonding material is used to bond the honeycomb cells **800***a-f* to the mask frame.

The honeycomb cells **800***a-f* become deflated when the air is released. This deflating procedure is achieved by means of opening the air inlet valve **250** and compressing the central spring **242**. In the deflated state, the adjacent honeycomb cells **800***a-f* are collapsed on to each other, and the overall dimension of the sound muffling chamber **110** is substantially reduced, making it easier for the user to carry, e.g., around the neck or in a backpack.

FIGS. **9**A and **9**B illustrate perspective views of an embodiment of the slats **240***a-g* and the spring **242** of the sound muffling chamber **110** in more detail. The slats **240***a-g* include a plurality of thin rectangular members made with rigid and lightweight materials (such as polymers, graphite, woods, metals, or other suitable material). The height of each slat **240***a-g* ranges between 0.1 mm to 5 mm. Each slat **240***a-g* attaches to the superior face of a lower honeycomb cell **800***a-e* and an inferior face of an upper, contiguous honeycomb cell **800***a-f*. In this way, each honeycomb cells **800***a-f* is connected to an adjacent honeycomb cells **800***a-f* using the slats **240***a-g*.

In one embodiment, one or more of the slats **240***a-g* extend from a lateral side of the rim **204** to the spring **242**. For example, in a right portion of the sound muffling chamber **110**, the medial slats **240***b-f* shown in FIG. **9**A extend from the right lateral rim **204** to at least the spring **242** in a central section of the sound muffling chamber **110**. An edge of each of the medial slats **240***b-f* forms a notch **900***a-e* to accept a lateral half of a turn of the spring **242**.

In an embodiment, the top slat **240***a* and the bottom slat **240***g* extend the length of the sound muffling chamber **110**, e.g., from the left lateral rim **204** to a right lateral rim **204**. The top and bottom slats **240***a,g* each include a notched or thinner medial portion **910***a,b* that extends through a space between two coils of the spring **242**. The top and bottom slats **240***a,g* are thus configured to extend lengthwise through the spring **242** while the medial slats **240***b-f* (in both the right and left portions of the sound muffling chamber **110**) extend to and end at the spring **242**.

In other embodiments, all of the slats **240***a-g* may extend lengthwise through the spring **242** and across the width of the sound muffling chamber **110** and/or all of the slats **240**-*a-g* may extend from a lateral side of the rim **204** and end at the spring **242** and/or any combination of the two embodiments. The honeycomb cells **800***a-f* need to be modified depending on the embodiment of the slats **240***a-g*.

FIGS. **10**A-B illustrate perspective views of an embodiment of the headband in more detail. The inner headband **210** is attached to the outer headband **280** by the one or more clasps **212***a-d*. The outer headband **280** is rotatably attached to the lateral body of the sound muffling chamber **110** at a right base **290***a* and a left base **290***b* such that the outer headband **280** and inner headband **210** rotate between 90 degrees to 180 degrees from a horizontal plane with respect to the sound muffling chamber **110**. When in use, the outer headband **280** may be positioned at approximately 90 degrees from a horizontal plane to fit over the head of a user. When not in use, the outer headband **280** may be rotated to approximately 180 degrees.

The rotation of the outer headband **280** may be limited by a rotation-stopping mechanism **284** positioned on an apex of the inner headband **210** and connected to the outer headband **280**, e.g., by a compression spring **282**. The inner headband **210** is similarly shaped as the outer headband **280** and includes a first vertical lateral member **214***a* and second vertical lateral member **216***a* and hemi-circular top member **216** that connects to the vertical lateral members **214***a,b*. The base of at least one of the vertical lateral members **214***a,b* forms saw-tooth ridges that are designed to mate with saw-tooth ridges formed on the right base **290***a* and/or left base **290***b* of the lateral body **500**. When the inner headband **210** is pulled close to the outer headband **280**, the inner headband base **218** is disengaged from the lateral body **500**, rendering it free to rotate. When the inner headband **210** is released from the outer headband **280**, the base of the inner headband **210** locks via the saw-tooth engagement members. The inner headband apex is configured to stably interface with the crown of the user's head.

FIGS. **11**A and **11**B illustrate embodiments of the sound egress channel **220** in more detail, wherein FIG. **11**A illustrates a side exploded view of components of the sound egress channel **220** and FIG. **11**B illustrates a perspective exploded view of components of the sound egress channel **220**.

In use, the sound waves from the user's voice enter the outlet port **122** from the sound muffling chamber **110**, are slowed through the sound decelerator **120**, and then guided into the sound silencing chamber **132**. The sound silencing chamber **132** includes a speaker **134** that emits out of phase sound waves in response to the voice cancellation signal from the DSP system **136**. The out of phase sound waves are superimposed and allowed to destructively interfere to reduce amplitude or eliminate the vocal sound waves of the user's voice. The mixed sound waves travel through the terminal conduit **138** and exit from the air outlet port **140**. The terminal conduit **138** may also include a sound decelerator **224** to slow the exit of the mixed sound waves and/or slow or inhibit the entry of external noises.

FIG. **12** illustrates a schematic block diagram of an embodiment of the transmission system **114** in more detail. The microphone **112** is disposed in the interior of the sound muffling chamber **110** to detect the user's voice, which is then transmitted to the transmission system **114**. The transmission system **114** includes, e.g., a wireless transmitter circuit **1210**, such as Bluetooth transmitter circuit or other short-link radio technology. In another embodiment, a wired transmitter and auxiliary cables may be implemented. The wireless transmitter **1210** is coupled to a battery **1220** and an antenna **1230** and transmits to one or more user devices, such as a smart phone, watch, laptop, speaker, or other device.

FIG. **13** illustrates a schematic block diagram of an embodiment of the DSP system **136** in more detail. In an embodiment, the DSP system **136** generates a voice cancellation signal that is complementary to the voice signal, e.g., wherein the complementary relationship means the two signals are approximately 180 degrees out of phase but have approximately the same amplitude and frequency. When the two resulting acoustic signals are superimposed on each other, the resulting mixed sound waves obtain a good muffling effect.

In an embodiment, the microphone **112** in the sound muffling chamber **110** generates a voice signal that is transmitted to the DSP system **136**. The DSP system **136** includes a pre-filter and/or analog to digital converter (ADC) **1310** that receives the analog voice analog and generates a digital voice signal. In another example, the pre-filter and/or ADC **1310** may alternatively be incorporated into the microphone **112**.

A signal analyzer **1320** in the DSP system **136** analyzes the digital voice signal and determines the various frequency components in the digital voice signal. For example, during a conversation, the fundamental frequency of a typical voice ranges from 250 Hertz (Hz) to 4000 Hz. Table 1 below illustrates one example of the major octave bands that contribute to speech intelligibility.

Frequency Bands in Hz	Contributions %
250	5%
500	15%
1000	20%
2000	30%
4000	25%

The DSP system **136** determines the frequency components in the digital voice signal, e.g., using a spectrum analyzer. The DSP system **136** also determines the amplitude and phase of the frequency components. For example, the signal analyzer **1320** may be a circuit or a logic unit that can extract characteristic parameters of acoustic signals by performing sampling, spectrum analysis, etc.

A signal generator **1330** in the DSP system **136** then generates a digital voice cancellation signal that includes frequency components with a same frequency and amplitude as the voice signal but at 180 degrees out of phase from the frequency components in the digital voice signal. The signal generator **1330** may include one or more of: logic units, integrated circuits, amplifiers, filters, clock circuits, etc. A post filter and digital to analog converter (DAC) **1340** converts the digital voice cancellation signal into an analog signal that is transmitted to the speaker **134**. In another example, the post filter and/or DAC **1340** may be implemented within the speaker **134**. The speaker **134** then generates analog sound waves in response to the digital voice cancellation signal. When the generated analog sound waves and the voice sound waves mix in the sound silencing chamber **132**, the sound waves are superimposed and cancel out amplitudes of the frequency components, at least to some extent, to generate softer, unintelligible sounds.

A good voice cancelling effect can be achieved when the phase of the generated sound waves and the vocal sound waves are opposite, and the amplitude and the frequency are the same. However, the embodiments are not limited thereto, for example, at least some voice canceling effects can be achieved when the generated sound waves and the vocal sound waves have somewhat or close to opposite phase (e.g., 170 degrees to 190 degrees out of phase) and/or have approximately same or similar amplitudes and frequencies (e.g., within 10% to 20%).

In an embodiment, the generated sound waves are emitted by the speaker **134** simultaneously to, or close to, the arrival of the vocal sound waves in the sound silencing chamber **132**. Since the speed of sound in air is approximately 331.5 meters/second (m/s), the sound decelerator **120** needs to increases the distance to the sound silencing chamber **132** and/or slow the sounds waves to the sound silencing chamber **132** to provide the DSP system **136** sufficient time to generate the voice cancellation signal. In one example, the time of the sound waves to reach the sound decelerator is at least 0.5 milliseconds (msec). In general, this 0.5 msec provides sufficient time for the DSP system **136** to generate the voice cancellation signal and for the speaker **134** to generate sound waves.

In an embodiment, the DSP system **136** may vary the time of transmitting the voice cancellation signal to the speaker **134** depending on a frequency component and its time to travel to the sound silencing chamber **132**. For example, as shown in Table 1 below, the travel time of a sound wave depends on its frequency and wavelength. Table 1 illustrates various frequencies of a human voice, the distance of a half wavelength of the frequency, and travel time of the half wavelength.

TABLE 1

FREQUENCY in Hz	Half Wavelength in mm	Time to travel Half Wavelength distance in msec
250	686	2.0
500	343	1.0
1,000	172	0.5
2,000	86	0.25
3,000	57	0.17
4,000	43	0.13
8,000	21	0.06

In an embodiment, the time for various frequency components to travel to the sound silencing chamber **132** may be predetermined, e.g., through experimentation. The DSP system **136** may then vary the time of transmitting the voice cancellation signal for different frequency components depending on the predetermined travel time.

The speaker **134** in the sound silencing chamber **132** is connected to the DSP system **136** and is configured to output the generated sound waves in response to the voice cancellation signal. In the arrangement, the generated sound waves and the vocal sound waves of opposite phase should be emitted from two mutually close positions to directly superimpose without attenuation. For example, the speaker **134** should be positioned close to the audio opening from the sound decelerator **120** into the sound silencing chamber **132**.

The DSP system **136**, and components thereof, may be implemented by hardware circuits and/or logic circuits including a memory and processor, wherein corresponding computer readable instructions stored in the memory are executed on the processor to cause the processor to perform operations described herein.

FIG. **14** illustrates a schematic block diagram of another embodiment of the DSP system **136** in more detail. In this embodiment, the DSP system **136** also compensates for ambient noise. An external microphone **142** is positioned on an external wall of the voice cancellation system **100** and/or within the air outlet **140** to detect ambient noises, such as external noises and/or sounds emitted from the terminal conduit **138**. The external microphone **142** detects the ambient noises and generates a noise signal that is transmitted to the DSP system **136**.

In an embodiment, the DSP system **136** processes the noise signal and generates a noise cancellation signal. For example, the DSP system **136**, similar to the process for the voice signal, analyzes the noise signal and determines a plurality of frequency components in the noise signal. The DSP system **136** also determines characteristic parameters for the frequency components, such as amplitude and phase. The DSP system **136** then generates a noise cancellation signal including frequency components at a same frequency and amplitude but with an opposite phase, e.g., 180 degrees out of phase, from the frequency components in the noise signal. The noise cancellation signal is transmitted to the speaker **134** to generate sound waves to muffle the ambient noise. In this way, the voice cancellation system **100** can effectively reduce or even eliminate a volume of the user's call sound on the surrounding environment, thus preventing others from being disturbed, and preventing the content of the call from being understood by others.

In addition and/or alternatively, in an embodiment, the DSP system **136** filters ambient noise from the voice signal. The external noises and/or sounds from the sound silencing chamber **132** may travel to the voice microphone **112** in the sound muffling chamber **110**. The voice microphone **112** may detect these noises along with the voice of the user. To isolate the voice sound waves from the ambient noise, the DSP system **136** may need to filter the noises from the voice signal, especially when the user is in a noisy environment such as a crowded room or on a busy street. For example, the DSP system **136** may include a noise filter **1350** that filters the noise signal from the voice signal. Though the noise filter **1350** is shown after the pre-filter/ADC **1310**, the noise filter **1350** may be implemented with and/or before the pre-filter or with or after the ADC. In addition, though the noise filter **1350** is shown before the signal analyzer **1320**, the noise filter **1350** may be implemented with the signal analyzer. For example, the signal analyzer **1320** can compare the characteristic parameters of the noise signal with the characteristic parameters of the voice signal, and eliminate the interference of the noise signal.

FIG. **15** illustrates a perspective view of another embodiment of the voice cancellation system **100**. In this embodiment, the sound silencing chamber **132** may be disposed in the outer headband **280** between two sound decelerators **120***a* and **120***b* located on each lateral side of the outer headband **280**. In this example, the user's voice travels from two openings in opposing sides of the sound muffling chamber **110** through elbows **124***a* and **124***b* and into the two sound decelerators **120***a* and **120***b*. Placing the sound silencing chamber **132** equidistance from each sound decelerator **120***a*, **120***b* is critical so that the user's voice arrives at the same time. In this embodiment, the sound decelerators **120***a,b* may have a greater length and provide further delay for processing of the voice signal.

FIGS. **16**A and **16**B illustrate views of another embodiment of the sound silencing chamber **132**, wherein FIG. **16**A illustrates a side perspective view of the sound silencing chamber **132**, and FIG. **16**B illustrates an exploded view of components of the sound silencing chamber **132**. The sound silencing chamber **132** is a small chamber where the vocal sound waves of the user's voice and the out of phase sound waves from the speaker **134** are superimposed. The sound silencing chamber **132** includes an elongated inner chamber **1602** having a tubular body with a first end fluidly coupled to the sound decelerators **120***a*, **120***b* and serving as the entry way for the vocal sound waves of the user's voice. The second end of the inner chamber **1602** includes or is fluidly coupled to the speaker **134** for broadcast of the out of phase sound waves. The user's voice thus reaches the sound silencing chamber **132** via the first sound decelerator **120***a* and the second sound decelerator **120***b*. The connector tubes of the first and second sound decelerators **120***a*, **120***b* are bent 90 degrees, the distal ends of which are brought in parallel to each other and placed on one end of the sound silencing chamber **132**. The speaker **134** is positioned on the opposite end of the sound silencing chamber **132** for broadcast of the out of phase sound waves. The speaker **134**, furthermore, is sized and configured to precisely mirror that of the vocal sound entry way.

The inner chamber **1602** is covered with an air-tight and/or sound proofed enclosure **1604** to prevent sound leakage. The inner chamber **1602** and enclosure **1604** may be lined with a sound absorbing material such as foam, fabric, and fibers to minimize echoing. Disposed circumferentially on the tubular body of the inner chamber **1602** at the longitudinal center point are formed one or more sound escaping holes **1606** for egress of the superimposed and cancelled sound waves into the enclosure **1604**.

The cancelled sound waves escape the enclosure **1604** through openings **1614***a*, **1614***b* to terminal segments **1608***a*, **1608***b*. The terminal segments **1608***a*, **1608***b* are positioned on opposing walls of the enclosure **1604** and serve to further attenuate the cancelled sound waves and block the external sounds from entering the device. To that end, the terminal segments **1608***a*, **1608***b* may be filled with a sound absorbing material and may include external openings **1612***a*, **1612***b* with porous coverings **1610***a*, **1610***b*, such as louver, to reduce the possibility of external noise retrogradely transmitting to the sound muffling chamber **110**. The external openings **1612***a*, **1612***b* and the terminal segment air passage each include at least a 7 mm diameter or greater to facilitate the user's adequate ventilation.

The maximum effects of destructive interference between the vocal sound waves and the speaker sound waves are achieved through various means: (1) The arrival time of these two sounds are synchronized; (2) The phase difference of these two sounds are set at 180 degrees; (3) The size and configuration of the two sounds' entry ways are precisely or approximately matched; (4) The two sounds' entry ways are positioned on the opposite walls of the sounds silencing chamber **132** so that the two sound waves travel directly toward each other. As such, the maximum voice cancellation occurs in the center of the sound silencing chamber **132**. Through destructive interference effects of the inverted-phase sounds, the majority of the user's voice is canceled, making it unintelligible to people nearby. Targeted cancellation voice frequency includes 250, 500, 1000, 2000, 4000 Hz. With this approach, a majority (>95%) of the speaker's voice is canceled, making it unintelligible to the nearby people.

The voice cancellation system **100** described herein enhances a user's privacy and minimizes disturbance to the public. It covers the nose and the mouth of the user in an air-tight manner and detects the vocal sounds created by both the nose and the mouth of the user while allowing the user to inhale and exhale without limitations and without risking sound leakage. The sound-barrier property of the device is robust such that leaking of vocal sounds is limited through the body of the device and sufficiently elastic to accommodate the facial movement and mouth opening and closing without disrupting the air-proof seal. The device is also foldable to permit the user to conveniently carry it.

As may be used herein, the term "operable to" or "configurable to" indicates that an element includes one or more of circuits, instructions, modules, data, input(s), output(s), etc., to perform one or more of the described or necessary corresponding functions and may further include inferred coupling to one or more other items to perform the described or necessary corresponding functions. As may also be used herein, the term(s) "coupled," "coupled to," "connected to" and/or "connecting" or "interconnecting" includes direct connection or link between nodes/devices and/or indirect connection between nodes/devices via an intervening item. As may further be used herein, inferred connections (i.e., where one element is connected to another element by inference) includes direct and indirect connection between two items in the same manner as "connected to." As may be used herein, the terms "substantially" and "approximately" provides an industry-accepted tolerance for its corresponding term and/or relativity between items.

Note that the aspects of the present disclosure may be described herein as a process, many of the operations can be performed in parallel or concurrently. In addition, the order of the operations may be re-arranged. A process is terminated when its operations are completed. A process may correspond to a method, a function, a procedure, a subroutine, a subprogram, etc. When a process corresponds to a function, its termination corresponds to a return of the function to the calling function or the main function.

The various features of the disclosure described herein can be implemented in different systems and devices without departing from the disclosure. It should be noted that the foregoing aspects of the disclosure are merely examples and are not to be construed as limiting the disclosure. The description of the aspects of the present disclosure is intended to be illustrative, and not to limit the scope of the claims. As such, the present teachings can be readily applied to other types of apparatuses and many alternatives, modifications, and variations will be apparent to those skilled in the art.

In the foregoing specification, certain representative aspects have been described with reference to specific examples. Various modifications and changes may be made, however, without departing from the scope of the present invention as set forth in the claims. The specification and figures are illustrative, rather than restrictive, and modifications are intended to be included within the scope of the present invention. Accordingly, the scope of the invention should be determined by the claims and their legal equivalents rather than by merely the examples described. For example, the components and/or elements recited in any apparatus claims may be assembled or otherwise operationally configured in a variety of permutations and are accordingly not limited to the specific configuration recited in the claims.

Furthermore, certain benefits, other advantages and solutions to problems have been described above with regard to particular embodiments; however, any benefit, advantage, solution to a problem, or any element that may cause any particular benefit, advantage, or solution to occur or to become more pronounced are not to be construed as critical, required, or essential features or components of any or all the claims.

As used herein, the terms "comprise," "comprises," "comprising," "having," "including," "includes" or any variation thereof, are intended to reference a nonexclusive inclusion, such that a process, method, article, composition or apparatus that comprises a list of elements does not include only those elements recited, but may also include other elements not expressly listed or inherent to such process, method, article, composition, or apparatus. Other combinations and/or modifications of the above-described structures, arrangements, applications, proportions, elements, materials, or components used in the practice of the present invention, in addition to those not specifically recited, may be varied or otherwise particularly adapted to specific environments, manufacturing specifications, design parameters, or other operating requirements without departing from the general principles of the same.

Moreover, reference to an element in the singular is not intended to mean "one and only one" unless specifically so stated, but rather "one or more." Unless specifically stated otherwise, the term "some" refers to one or more. All structural and functional equivalents to the elements of the various aspects described throughout this disclosure that are known or later come to be known to those of ordinary skill in the art are expressly incorporated herein by reference and are intended to be encompassed by the claims. Moreover, nothing disclosed herein is intended to be dedicated to the public regardless of whether such disclosure is explicitly recited in the claims. No claim element is intended to be construed under the provisions of 35 U.S.C. § 112(f) as a "means-plus-function" type element, unless the element is expressly recited using the phrase "means for" or, in the case of a method claim, the element is recited using the phrase "step for."

As used herein, the term "determining" encompasses a wide variety of actions. For example, "determining" may include calculating, computing, processing, deriving, investigating, looking up (e.g., looking up in a table, a database, or another data structure), ascertaining, and the like. Also, "determining" may include receiving (e.g., receiving information), accessing (e.g., accessing data in a memory), and the like. Also, "determining" may include resolving, selecting, choosing, establishing, and the like.

Any reference to an element herein using a designation such as "first," "second," and so forth does not generally limit the quantity or order of those elements. Rather, these designations may be used herein as a convenient method of distinguishing between two or more elements or instances of an element. Thus, a reference to first and second elements does not mean that only two elements may be used there or that the first element must precede the second element in some manner. Also, unless stated otherwise a set of elements may include one or more elements. In addition, terminology of the form "at least one of a, b, or c" or "a, b, c, or any combination thereof" used in the description or the claims means "a or b or c or any combination of these elements." For example, this terminology may include a, or b, or c, or a and b, or a and c, or a and b and c, or 2a, or 2b, or 2c, or 2a and b, and so on.

Those of skill in the art will appreciate that information and signals may be represented using any of a variety of different technologies and techniques. For example, data, instructions, commands, information, signals, bits, symbols, and chips that may be referenced throughout the above description may be represented by voltages, currents, electromagnetic waves, magnetic fields or particles, optical fields or particles, or any combination thereof.

The subject matter described herein may be implemented in hardware, software, firmware, or any combination thereof. As such, the terms "function," "module," and the like as used herein may refer to hardware, which may also include software and/or firmware components, for implementing the feature being described. In one example implementation, the subject matter described herein may be implemented using a computer readable medium having stored thereon computer executable instructions that when executed by a computer (e.g., a processor) control the computer to perform the functionality described herein. Examples of computer-readable media suitable for implementing the subject matter described herein include non-transitory computer-readable media, such as disk memory devices, chip memory devices, programmable logic devices, and application specific integrated circuits. In addition, a computer readable medium that implements the subject matter described herein may be located on a single device or computing platform or may be distributed across multiple devices or computing platforms.

The invention claimed is:

1. A voice cancellation system, comprising:

a sound muffling chamber configured to cover both a nose and mouth of a user, wherein the sound muffling chamber includes soundproof material;

at least one microphone positioned in the sound muffling chamber, wherein the at least one microphone is configured to detect a voice of the user in the sound muffling chamber and generate a voice signal;

a sound silencing chamber, wherein the sound silencing chamber includes at least one speaker;

at least one sound decelerator fluidly coupled between the sound muffling chamber and the sound silencing chamber, wherein the sound decelerator includes material to increase a traveling time of sound waves from the sound muffling chamber to the sound silencing chamber;

a signal processing system configured to analyze the voice signal and generate a digital voice cancellation signal, wherein the voice cancellation signal includes one or more frequency components having a same frequency and amplitude but a 180 degrees out of phase from one or more frequency components of the voice signal; and

wherein the speaker generates analog sound waves in the sound silencing chamber in response to the digital voice cancellation signal.

2. The voice cancellation system of claim **1**, wherein the sound muffling chamber further comprises:

a plurality of slats;

a spring positioned centrally to the plurality of slats, wherein each of the plurality of slats includes at least a portion positioned in a different coil of the spring;

a plurality of inflatable air cells, wherein each of the plurality of inflatable air cells is positioned between a different pair of the plurality of slats; and

an airtight enclosure that encloses at least the plurality of slats and the plurality of inflatable air cells.

3. The voice cancellation system of claim **2**, wherein in a deflated state, the spring compresses the plurality of slats together and each of the plurality of inflatable air cells is deflated and folded between the different pair of the plurality of slats.

4. The voice cancellation system of claim **3**, wherein the sound muffling chamber further comprises:

a lock configured to hold the spring in an extended state; and

wherein in an inflated state, the spring is in the extended state and pushes the plurality of slats apart and each of the plurality of inflatable air cells is inflated and extends between the different pair of the plurality of slats.

5. The voice cancellation system of claim **4**, wherein the sound muffling chamber further comprises:

an inner wall coated with a sound-absorbing material; and

an outer wall, wherein the inner and outer wall are part of the air-tight enclosure enclosing at least the plurality of slats and the plurality of inflatable air cells.

6. The voice cancellation system of claim **2**, further comprising:

an air inlet pipe fluidly coupled to the plurality of inflatable air cells; and

an air valve coupled to the air inlet pipe, wherein in an open position, the air valve fluidly couples the air inlet pipe to an air source and in a closed position, fluidly decouples the air inlet pipe from the air source.

7. The voice cancellation system of claim 1, further comprising:

an outer headband rotatably coupled to the sound muffling chamber such that the outer headband rotates between 90 degrees to 180 degrees from a horizontal plane with respect to the sound muffling chamber.

8. The voice cancellation system of claim 1, further comprising:

an elbow-shaped connector tube with a first end fluidly coupled to the sound muffling chamber, and a second end fluidly coupled to the at least one sound decelerator.

9. The voice cancellation system of claim 1, wherein the sound muffling chamber further comprises:

an inner rim contoured to fit over the mouth and the nose of the user, wherein the inner rim includes an elastic material to create an air-tight seal with a skin of the user.

10. A voice cancellation system, comprising:

a sound muffling chamber configured to cover both a nose and mouth of a user, wherein the sound muffling chamber includes soundproof material;

at least one microphone positioned in the sound muffling chamber, wherein the at least one microphone is configured to detect voice sound waves of the user in the sound muffling chamber and generate a voice signal;

a headband coupled to the sound muffling chamber, wherein the headband includes a tubular structure configured to extends circumferentially from the sound muffling chamber over a head of the user;

a sound silencing chamber positioned near an apex of the headband, wherein the sound silencing chamber includes at least one speaker;

at first sound decelerator in a left side of the tubular structure of the headband, wherein the first sound decelerator is fluidly coupled between a left side of the sound muffling chamber and the sound silencing chamber;

a second sound decelerator in a right side of the tubular structure of the headband, wherein the second sound decelerator is fluidly coupled between a right side of the sound muffling chamber and the sound silencing chamber;

a signal processing system configured to analyze the voice signal and generate a voice cancellation signal; and

wherein the at least one speaker generates analog sound waves in the sound silencing chamber in response to the digital voice cancellation signal.

11. The voice cancellation system of claim 10, wherein the first sound decelerator includes at least one first tortuous sound conduit that may be filled with sound retarding materials to increase a traveling time of the voice sound waves from the left side of the sound muffling chamber to the sound silencing chamber;

wherein the second sound decelerator includes at least one second tortuous sound conduit that may be filled with porous sound retarding materials to increase a traveling time of the voice sound waves from the right side of the sound muffling chamber to the sound silencing chamber;

wherein the increase of sound transmission time through each of the first and second decelerators is at least the time required for the signal processing system to process the voice signal and produce the voice cancellation signal in the sound silencing chamber;

wherein the at least first one tortuous sound conduit and the at least second one tortuous sound conduit may each be of spiral, convoluted, zigzag, helical, wavy, or labyrinthine pattern; and

wherein each of the first and second decelerators are enclosed with a soundproof enclosure.

12. The voice cancellation system of claim 10, wherein the signal processing system is configured to:

determine a plurality of voice frequency components in the voice signal;

determine an amplitude and phase for each of the plurality of voice frequency components; and

generate the voice cancellation signal including a plurality of cancellation frequency components, wherein each of the plurality of cancellation frequency components has a same frequency and amplitude but is a 180 degrees out of phase from at least one of the plurality of voice frequency components; and

wherein the at least one speaker generates sound waves in the sound silencing chamber in response to the voice cancellation signal to muffle the voice sound waves.

13. The voice cancellation system of claim 10, wherein the sound silencing chamber, comprises:

an inner chamber having a tubular body, wherein a first lateral portion of the inner chamber is fluidly coupled to the first sound decelerator and the second sound decelerator and wherein a second lateral portion of the inner chamber includes the at least one speaker; and

wherein one or more holes are formed centrally of the tubular body of the inner chamber for air flow.

14. The voice cancellation system of claim 13, wherein the sound silencing chamber further comprises:

a sound proofed enclosure around at least a portion of the inner chamber, wherein the sound proofed enclosure forms a first opening and a second opening, wherein the first opening is fluidly coupled to a first terminal conduit and the second opening is fluidly coupled to a second terminal conduit;

wherein the conduit forms one or more holes fluidly coupled to the first opening and the second opening of the conduit enclosure.

15. The voice cancellation system of claim 14, wherein the first terminal conduit and the second terminal conduit are positioned on opposing sides of the sound proofed enclosure and wherein each of the first terminal conduit and the second terminal conduit include external openings;

wherein the first terminal conduit and the second terminal conduit include a tortuous structure and are filled with porous sound retarding materials; and

wherein the external openings of the first terminal conduit and the second terminal conduit each include a porous cover.

16. The voice cancellation system of claim 10, wherein the sound muffling chamber further comprises:

a plurality of slats;

a spring positioned centrally to the plurality of slats, wherein each of the plurality of slats includes at least a portion positioned in a different coil of the spring; and

a plurality of inflatable air cells, wherein each of the plurality of inflatable air cells is positioned between a different pair of the plurality of slats.

17. The voice cancellation system of claim 16, wherein in a deflated state, the spring compresses the plurality of slats together and each of the plurality of inflatable air cells is deflated and folded between the different pair of the plurality of slats.

18. The voice cancellation system of claim **17**, wherein the sound muffling chamber further comprises:

a lock configured to hold the spring in an extended state; and

wherein in an inflated state, the spring is in the extended state and pushes the plurality of slats apart and each of the plurality of inflatable air cells is inflated and extends between the different pair of the plurality of slats.

19. The voice cancellation system of claim **18**, further comprising:

an air inlet pipe fluidly coupled to the plurality of inflatable air cells;

an air valve coupled to the air inlet pipe, wherein in an open position, the air valve fluidly couples the air inlet pipe to an air source and in a closed position, fluidly decouples the air inlet pipe from the air source; and

a pressure gauge fluidly coupled to the air inlet pipe and/or the air valve, wherein the pressure gauge measures an air pressure in the plurality of inflatable air cells.

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